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WATER PLANT OPTIMIZATION STUDY

KITCHENER WATER SUPPLY

JANUARY 1994

Ontario

Ministry of
Environment
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Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of Environment and Energy.

Note, all references to Ministry of the Environment in this report should read Ministry of Environment and Energy.

WATER PLANT OPTIMIZATION STUDY
KITCHENER WATER SUPPLY

SUMMARY OF FINDINGS AND RECOMMENDATIONS

The purpose of the Water Plant Optimization Study (WPOS) for the Kitchener water supply is generally twofold:

1. To document and review the present quality and quantity of Kitchener ground water supplies, and to define the existing treatment processes used at the Kitchener well fields.

2. To assess the optimization of disinfection/treatment of the Kitchener well fields, and to define the need for emergency planning procedures to protect the Kitchener ground water supplies.

In striving for excellence in water treatment it is important to examine all possible approaches, but first, optimum use should be made of the processes already in place.

This optimization study is a beginning and not an end to itself; it is the start of an ongoing documentation of the operation of three well fields in Kitchener: Strange Street, Mannheim and Woolner. It is recommended that this document be updated on an annual basis and expanded to include other Kitchener ground water supplies.

It was found that Woolner Well K80, and to a lesser extent Well K81, experience a seasonal taste and odour problem. Treatment could include GAC adsorption; however, a permanent or portable GAC unit is expensive and may not be justifiable for this problem only.

The most effective means of identifying taste and odour events at the Woolner well field appear to be through the use of a Flavour Panel and observing algal growth in the Grand River.

At the Strange Street well field, treatment is not required for present TCE concentrations in well K12. If TCE levels increase and approach drinking water guidelines, the treatment options include air stripping and activated carbon adsorption.

Physical Improvements

- Strange Street Wells K12 and K17 should be equipped with chlorination equipment to ensure better control of chlorine residuals in the Strange Street reservoir.

- All Mannheim wells should be chlorinated because of the number of service connections that presently exist on the well field transmission mains.

- All water in the Kitchener distribution system be disinfected.

- The Region should continue with a program of installing treated water sample lines a sufficient distance downstream of chlorination addition at the well head.

- Replace the existing orifice plate meters which measure well pumpage with more accurate propeller-type meters.

Studies

- All Kitchener weekly bacteriological samples should be analyzed for standards plate counts for at least the next year and possibly two years. This will determine the overall bacteriological quality of the Kitchener water supply. Bacteriological background analyses should be done as well.

- A field test at Woolner Well K80 should be carried out to determine the effectiveness of activated carbon in treating the seasonal taste and odour problem.

- Elevated iron and manganese levels at Strange Street Well K14 suggests the need for sequestering treatment. This treatment method should be evaluated further to determine its feasibility.

- There is a need for an expanded ground water quality monitoring program in Kitchener. An inventory and monitoring programs for past and present point sources of contamination is recommended.

- Further investigations are required on the feasibility of portable, trailer-mounted treatment systems for treating contaminated well water in emergency situations.

Other Recommendations

- The Region should increase the bacteriological sampling frequency to more than weekly as per the Ontario Drinking Water Objectives.

- The Region should develop a chlorination plan that sets clear goals, outlines a monitoring program and sets a staff training program.

- Monitor chlorine residuals at the Strange Street, Mannheim and Woolner wells and the Strange Street and Mannheim reservoirs on a daily basis. A chlorine residual analyzer tied into SCADA may be a preferred alternative to manually monitoring chlorine residuals.

- Train staff to follow standard procedures in taking bacteriological samples from the distribution system in order to minimize sampling errors.

- Bacteriological sampling locations in the distribution system would be representative of actual water quality, e.g. sample at household taps, and should not necessarily be taken from the same points on each occasion.

- The use of sodium chlorite at the river wells be discontinued

- Document well status on a daily basis, as opposed to weekly status now taken, so that monthly maximum and minimum well field flows are more accurate.

- Wilmot Township should implement a bacteriological sampling program in the Mannheim area where residents are supplied from the Mannheim well field.

- Add Strange Street Well K12 to the DWSP program for further monitoring.

It is noted that as of the date of publication some of the above recommendations may have already been implemented.

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INTRODUCTION AND TERMS OF REFERENCE

The Ontario Ministry of the Environment has instituted a Drinking Water Surveillance Program, consisting of a continuously updated base of information on Ontario water treatment plants and water quality. In connection with the surveillance program, a specific plant investigation and process evaluation study is desired for each plant entering the program i.e. an optimization study. The optimization study is to document and review the present conditions and to determine an optimum treatment strategy for contaminant removal at the plant. A Terms of Reference for the Water Plant Optimization Study (WPOS) has been prepared by the Ministry and distributed to the Consultants engaged for the Optimization Studies (refer to Appendix A). The Terms of Reference have been adjusted for the Kitchener WPOS because Kitchener is currently supplied by ground water. The Work Plan for the Kitchener WPOS is also included in Appendix A.

The purpose of the Water Plant Optimization Study for the Kitchener water supply is generally twofold:

1. To document and review the present quality and quantity of Kitchener ground water supplies, and to define the existing treatment processes used at the Kitchener well fields.

2. To assess the optimization of disinfection/treatment of the Kitchener well fields, and to define the need for emergency planning procedures to protect the Kitchener ground water supplies.

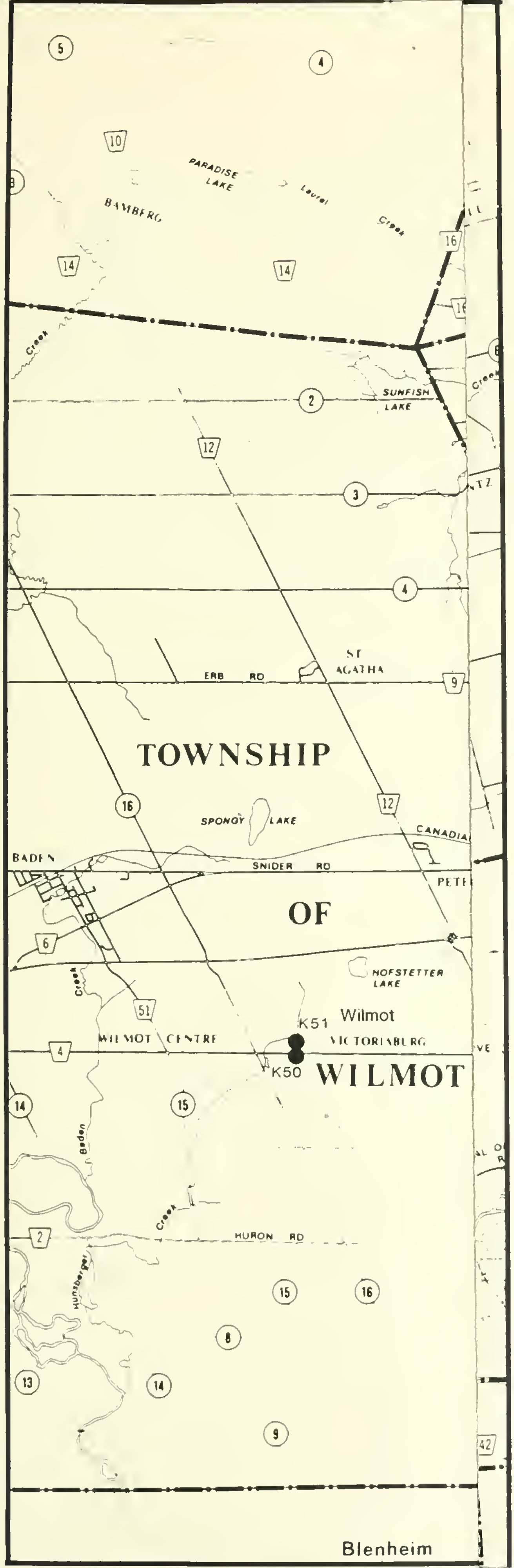
Development of ground water supplies for Kitchener has proceeded as municipal water demands grew. For example, the first ground water wells were constructed in the late 1800's in the central part of the City (Refer to Figure 1). As water demands grew, the well fields in the City centre were further developed until their total supply capabilities were reached. In the 1950's, the City began developing new well fields in the western part of Kitchener and also in Wilmot Township, just west of the municipal boundaries. The last well developed in this area was in 1971. Finally, in 1972, Kitchener developed two additional wells in Wilmot Township about 6.5 km from the City's western boundary

In essence, the City of Kitchener had to look farther and farther afield for new ground water supplies as the City grew.

Since 1974, induced infiltration systems have been developed along the Grand River to meet the growth in Kitchener water demands.

The Kitchener water supply system presently consists of seven well fields: Greenbrook, Strange Street, Mannheim East, Mannheim West, Parkway, Lancaster and Wilmot. The well fields are made up of 27 overburden wells. The water supply system also includes three induced infiltration systems along the Grand River (Forwell, Pompeii and Woolner), consisting of five horizontal collectors and four vertical infiltration wells.

The Kitchener ground water sources have a perennial yield of about 80.9 ML/day (17.8 mgd) and the well fields have a maximum capacity of approximately 119.3 ML/day (26.3 mgd).



LEGEND

●	Municipal Well
▼	Induced Infiltration Well
■	Ground Storage Reservoir
☐	Well Fields included in Kitchener WPOS
◆	Bacteriological Sampling Point
•—	Municipal Boundary

SCALE 1:50 000

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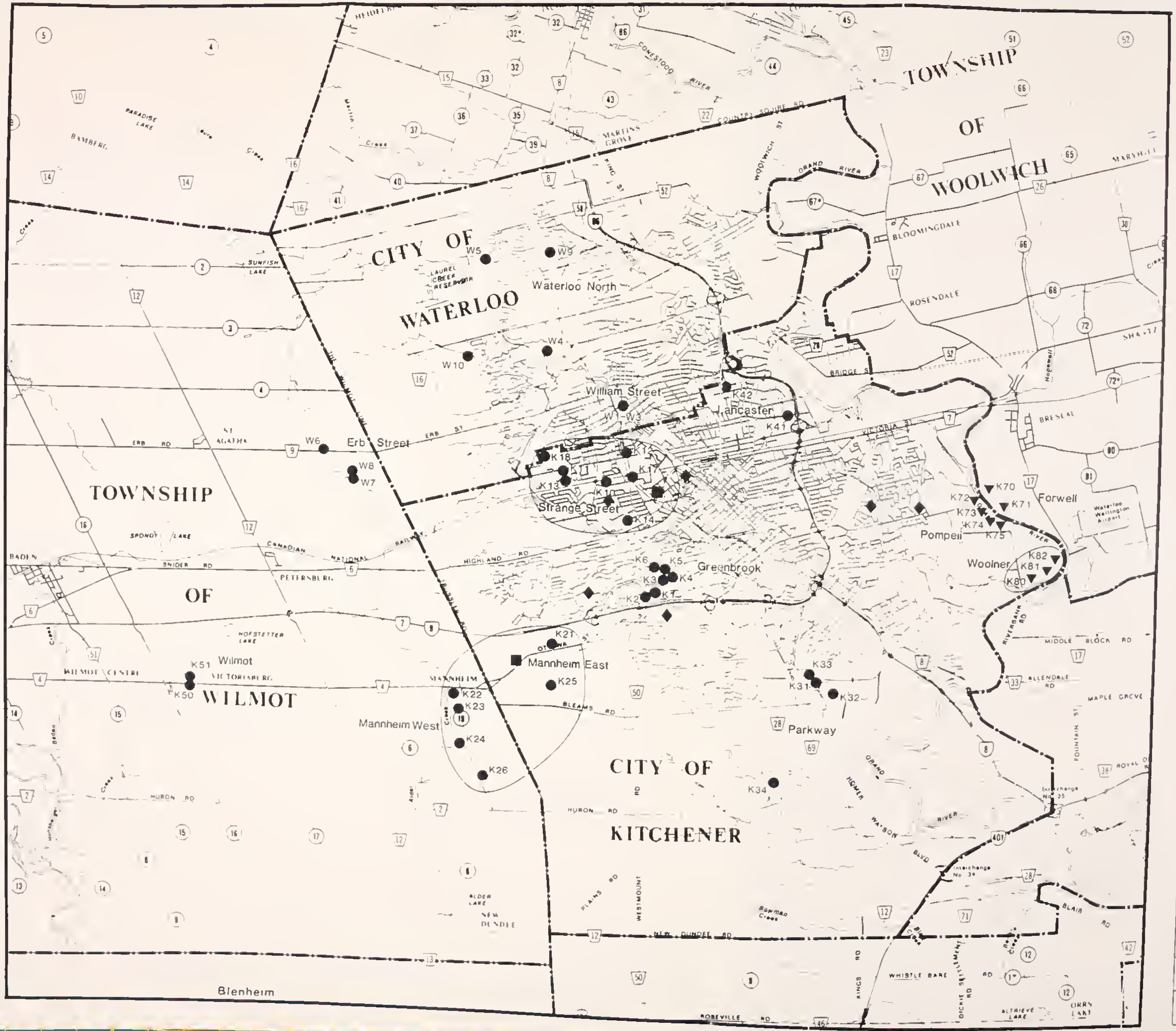
KITCHENER GROUND WATER
SUPPLIES

DILLON

January 1987

Figure 1



LEGEND

- ● Municipal Well
- ▼ Induced Infiltration Well
- ■ Ground Storage Reservoir
- ☐ Well Fields included in Kitchener WPOS
- ◆ Bacteriological Sampling Point
- -·- Municipal Boundary

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Kitchener Water Supply

KITCHENER GROUND WATER
SUPPLIES

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Figure 1

The perennial yield is defined as the average yield from the ground water sources that has been historically sustained without depleting aquifer storage. The maximum capacity is defined as the capacity available from a continuously pumping well field utilizing the full available drawdown over seven days

The Kitchener system currently supplies the City of Kitchener, a portion of the water needs in Waterloo, residents in a community of Mannheim in Wilmot Township and provides a water supply for fire demands in north Cambridge. The Kitchener system is not fluoridated.

It is not the intention of the Kitchener WPOS to investigate all 10 ground water sources (well fields and induced filtration systems), but to review a representative cross-section of the well fields that supply the system. Three well fields have been chosen for review in this study (see Figure 1):

Woolner:	An induced infiltration system located on the east side of Kitchener adjacent to the Grand River. This well field consists of three horizontal collectors.
Strange Street	One of the first well fields developed in Kitchener, located near the city-centre. It consists of seven overburden wells, five connected to an upper aquifer complex and two pumping from a lower aquifer complex.

The lower aquifer complex has limited distribution and is generally restricted to an area beneath the east flank of the Waterloo Moraine, in Kitchener and Waterloo. The coarsest formations occur at or near the bedrock surface and support the well fields at Greenbrook, Lancaster, Parkway and easterly Strange Street. The lower complex becomes thinner and finer grained to the east and west of this area.

The hydraulic interconnection between the upper and lower aquifer complexes is not accurately defined. Interconnection is indicated in some areas, but generally the complexes are separated by approximately 20 m (65 ft.) of fine-grained lacustrine and till formations. Also, the lateral extent of each complex may be disrupted as is apparent with a discontinuity in the upper complex between the Wilmot and Mannheim well fields.

In the Kitchener area it is believed that natural recharge is substantial, and likely exceeds 520 $m^3/day/km^2$ (0.3 mgd/sq.mile) throughout the developed aquifer area, which is approximately 25% of the average annual precipitation.

The crest of the Waterloo Moraine acts as a divide to ground water movement in the area. Generally, ground water flows east and west from the crest, except where locally disrupted by municipal well field withdrawals. The upland area of the moraine acts as a ground water recharge area demonstrated by the downward gradient in water levels in the upper, lower and bedrock complexes. The flank areas of the moraine, especially adjacent to major watercourses, act as ground water discharge areas where deep overburden and bedrock wells once flowed.

The existence of high-yield well fields east of the moraine strongly demonstrates that appreciable recharge from the moraine area reaches the deeper overburden and bedrock zones. Flowing conditions initially at the Greenbrook and Parkway wells suggest an interconnection between the moraine area and the lower aquifer complex, as the observed water levels must relate to a source at a higher elevation.

In general, ground water from the lower aquifer complex is more mineralized than ground water from the upper complex. The reasons are twofold:

- The level of mineralization in ground water increases with the length of flow path as it comes in contact with more soluble constituents of the overburden matrix. The lower complex has a longer flow path than the upper complex.

- There is an upward flow gradient from the bedrock zone to the lower aquifer complex in the easterly flank area of the moraine. The bedrock ground water is highly mineralized and therefore increases the level of mineralization in the lower complex ground water.

A.2 Strange Street Well Field

The Strange Street well field consists of seven overburden wells (K10, K11, K12, K13, K14, K17 and K18) located in north-central Kitchener. The well field is underlain by both the upper and lower aquifer complexes locally separated by fine-grained aquitards. The upper aquifer complex has variable thickness ranging from 4.6 to 12.2 m (15 ft. to 40 ft.) and is intercepted by wells K10, K11, K13, K17 and K18. The lower aquifer is approximately 15.3 m (50 ft.) thick locally and directly overlies the Salina bedrock formation. The lower aquifer appears to extend north to the William Street well field, south to the Greenbrook field, east to the Lancaster field, but the western extension is not defined. Wells K12 and K14 are completed in the lower complex.

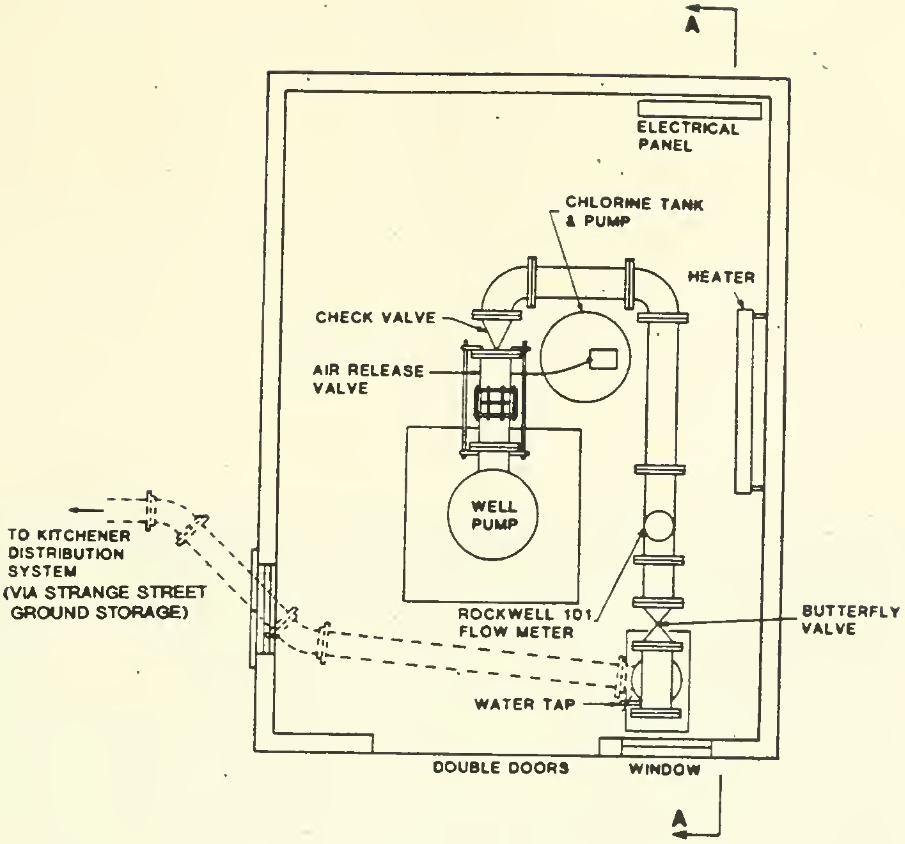
Figure 2 illustrates the well house layout for Strange Street Well K11. This layout is representative of a typical well in Kitchener. Figure 3 provides a photographic record of the inner works of well K11.

The perennial yield for the upper and lower aquifer complexes at the Strange Street well field is interpreted to be 9.1 ML/day (2.0 mgd). The total 7-day maximum capacity of the Strange Street well field is about 15.4 ML/day (3.4 mgd).

All wells except K14 and K18 pump to the 9.1 ML (2 mg) Strange Street ground storage reservoir. Wells K14 and K18 pump directly into the distribution system.

The ground water quality in the upper aquifer of the Strange Street well field varies from east to west. The eastern wells (K10 and K17) are more mineralized than the western wells (K11, K13 and K18) with higher hardness and chloride levels. The eastern wells may obtain some of their supply from the more mineralized lower aquifer complex. All Strange Street wells produce very hard water.

Well K14 has iron and manganese concentrations that exceed Ministry of the Environment (MOE) Drinking Water Objectives. For this reason, it is only used as a peaking well during high summer demands.



WELL HOUSE LAYOUT
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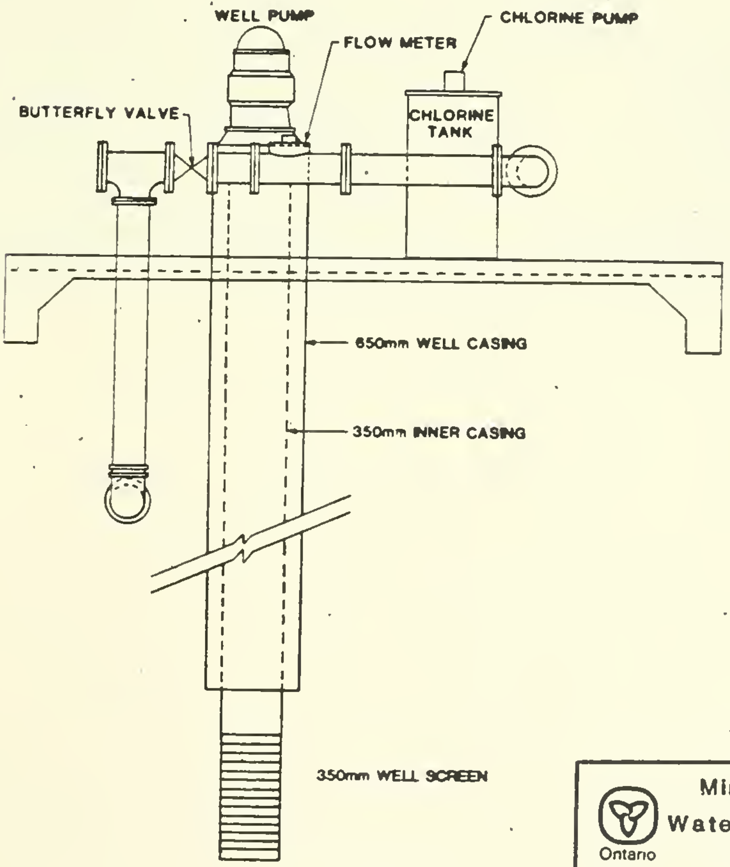

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STRANGE STREET WELL FIELD
WELL K11

DILLON

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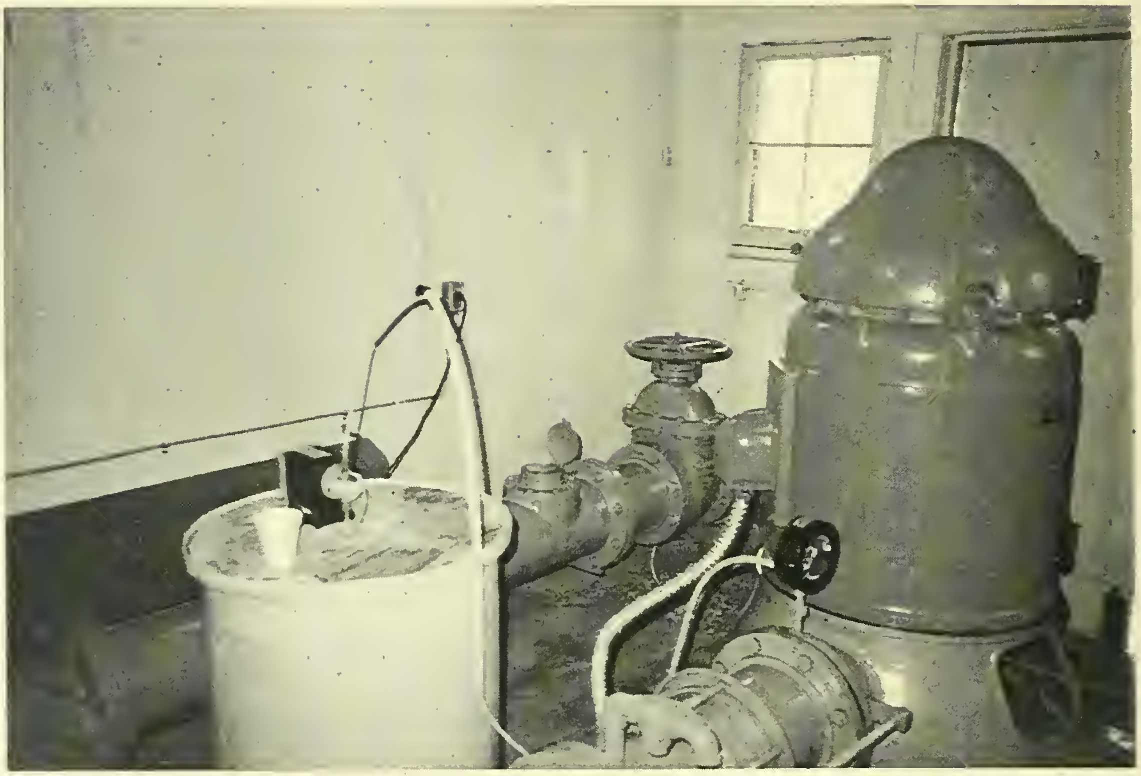
Figure 2



STRANGE STREET WELL K11
Chlorine tank and pump (left);
flow meter (centre);
well pump (right)

FIGURE 3

A.3 Mannheim East/West Well Fields

The Mannheim East well field is located near the crest of the Waterloo Moraine in west-central Kitchener. It consists of two high-capacity overburden wells (K21 and K25) completed in the upper aquifer complex. The upper aquifer consists of interbedded sand, gravel and boulders with a saturated thickness of 18.3 m (60 ft.), overlain by a thick section of unsaturated granular sediments and then mantled by a surficial till deposit.

The Mannheim West well field consists of four overburden wells (K22, K23, K24 and K26) located in Wilmot Township just outside the west municipal boundary of Kitchener. The developed aquifer forms part of the upper complex composed of sand, gravel and boulders ranging in thickness from 22.8 m (75 ft.) to 30.5 m (100 ft.). The upper aquifer complex has wider areal extent to the north, south and east, but grades into fine-grained sediments to the west of this well field.

The total perennial yield of the Mannheim East/West aquifer is estimated to be 23.6 ML/day (5.2 mgd). The total 7-day maximum yield of the Mannheim East/West wells is approximately 31.4 ML/day (6.9 mgd).

All Mannheim wells pump to the 50 ML (11 mg) Mannheim ground storage reservoir.

The ground water quality from the Mannheim East/West wells is good. The water is very hard, but contains low concentrations of iron, chloride, and sodium.

The Region's proposed new major water supply for Kitchener, Waterloo and Cambridge - the Mannheim Artificial Recharge Scheme - will be situated between the Mannheim East and West well fields.

Simply, the Mannheim Artificial Recharge Scheme involves taking water from the Grand River on the eastern boundary of Kitchener, pumping the water about 10 km through a pipeline to a gravel pit at the western boundary of Kitchener in the vicinity of the existing Mannheim well fields, treating the water and artificially recharging it using recharge basins and/or injection wells into the natural aquifer system in the vicinity of the gravel pit. The aquifer will act as a natural storage reservoir from which water will be recovered through a system of wells surrounding the gravel pit area. The recovery wells will pump to an expanded Mannheim ground storage reservoir.

The first phase of the Mannheim Scheme is due to be operational in 1991. The first phase will be a direct river supply; it will pass treated surface water direct to the distribution system while prototype testing of the recharge facilities is carried out.

A review of Grand River water quality found the river to be acceptable as a raw water source for a drinking water supply. In general, based on the available data, the raw water may be classed as a good source with the exception of bacterial quality which would be classed as marginally good to poor. This is to be expected for a river which receives run-off and discharges from a large drainage area containing urban and rural development (Reference: Environmental Study Report, Master Water Supply Study, Region of Waterloo, 1987).

A.4 Woolner Induced Infiltration System

The Woolner system consists of three horizontal collectors (K80, K81 and K82) located within a 700 m (2,300 ft.) stretch along the west bank of the Grand River in Kitchener, opposite the Waterloo-Wellington airport. The aquifer is comprised of sand, gravel and boulders ranging in thickness from about 9.2 m to 15.3 m (30 ft. to 50 ft.). The aquifer appears to be hydraulically connected to the river.

Figure 4 illustrates a typical well house layout for the Woolner horizontal collectors. Figure 5 provides a photographic record of Woolner well K80.

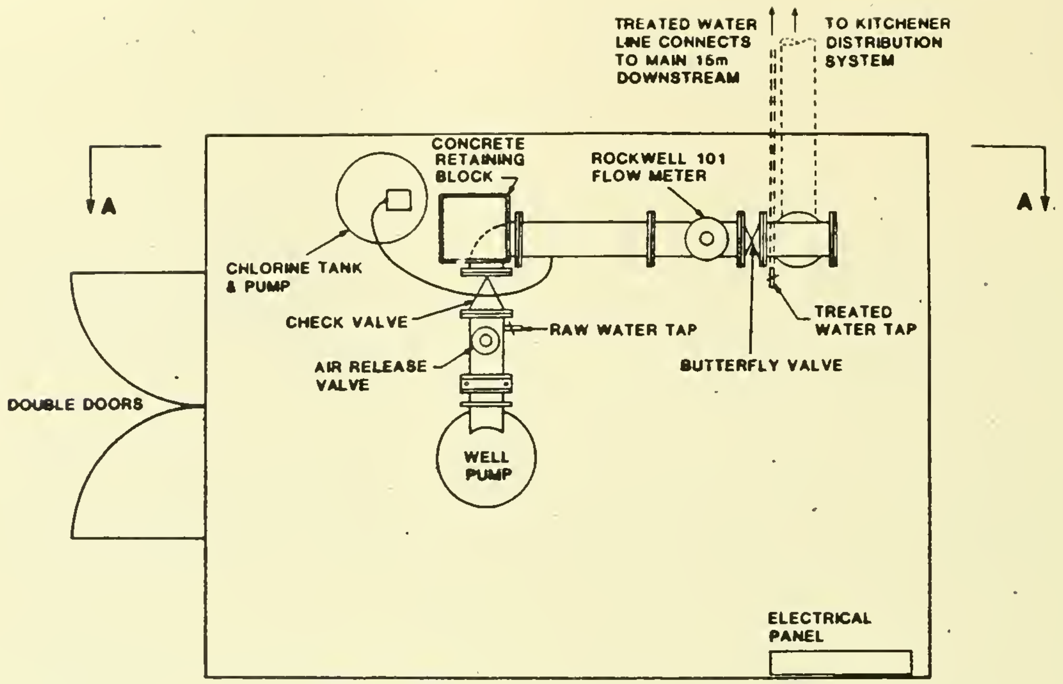
The collectors induce infiltration from the Grand River and also retrieve local ground water.

The perennial aquifer yield at Woolner is estimated to be 10.0 ML/day (2.2 mgd). The total 7-day maximum capacity of this well field is about 10.8 ML/day (2.4 mgd).

The collectors pump directly into the Kitchener water distribution system.

The water quality from the Woolner collectors is generally good. The water is very hard, but iron, chloride, sulphate and sodium concentrations are low. The hardness level from the collectors is higher than the river water hardness, suggesting that a portion of the recovered well water may be ground water, not all river water.

In four of the last five years a seasonal taste and odour problem has occurred with the induced infiltration wells. The Region of Waterloo has investigated the cause but concrete effects could not be determined. Therefore, no remedial measures are anticipated in the short-term.



TYPICAL WELL HOUSE LAYOUT
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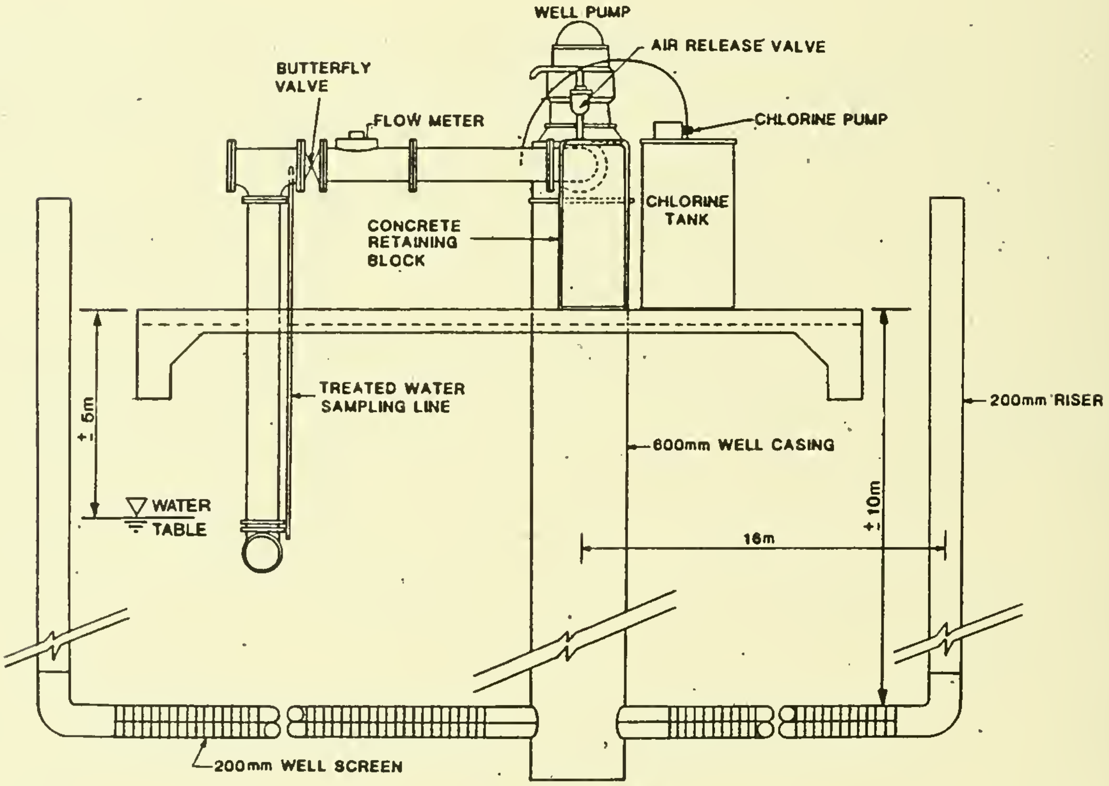

SECTION A-A
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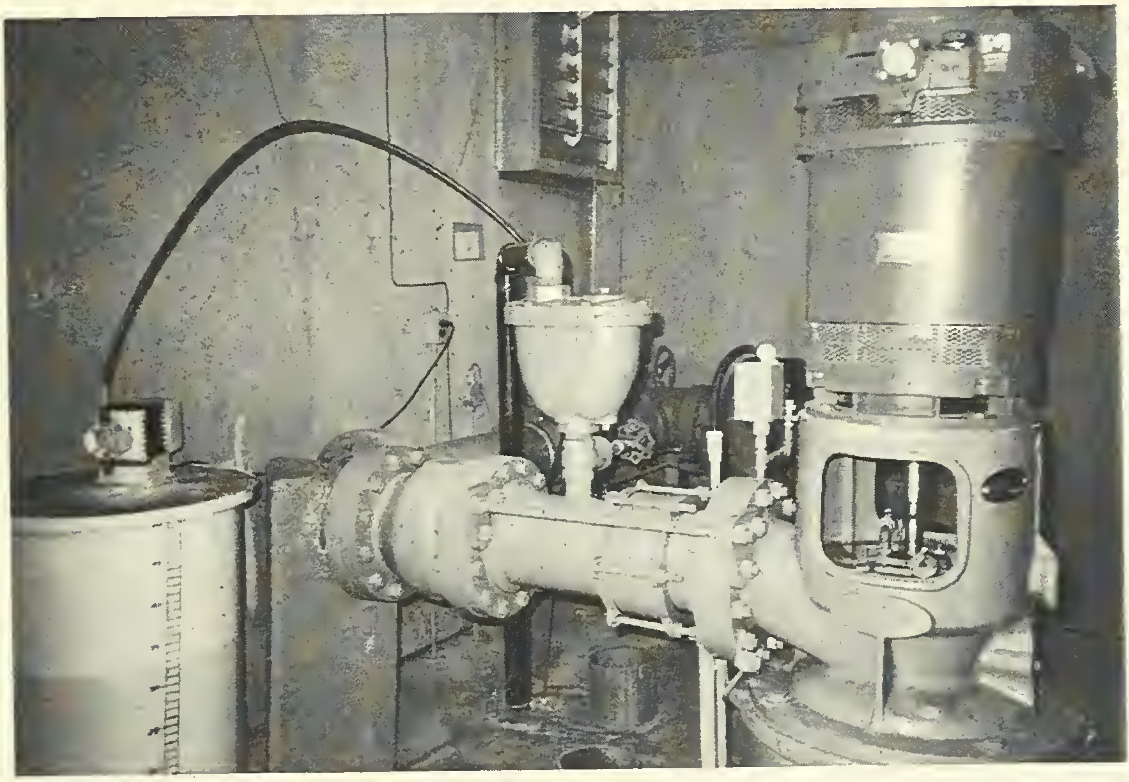
WOOLNER INDUCED
INFILTRATION SYSTEM
WELL K80

DILLON

January 1987

Figure 4



WOOLNER WELL K80

Chlorine tank and pump (left);
air release valve (centre);
well pump (right)

FIGURE 5

B. WELL FIELD PUMPAGE

B.1 Four Year Summary of Flow Records

Table 1.0 appended summarizes the monthly maximum, minimum and average flows for the years 1983 to 1986 for the Strange Street, Mannheim and Woolner well fields. Table 1.1 appended tabulates the daily flow readings taken during the same four year period for the three well fields.

The information in Tables 1.0 and 1.1 was derived from Region of Waterloo flow records. The Region usually takes a flow reading (pumping volume) once per week at each Kitchener municipal well, typically on a Friday. The meter reader also notes if the well is on or off at the time of the weekly visit. The weekly flow readings are totalled each month to give a monthly pumpage volume for each well.

The Region's Kitchener well field operator (stationed at the Greenbrook Pumping Station) keeps a daily record of the total hours each municipal well is in operation. The hours of operation are summed up each month to give monthly pumping hours for each well.

The Region calculates the average monthly pumping rate for each well by dividing the monthly pumpage volume by the hours of well operation.

The well field flows shown in Tables 1.0 and 1.1 (except for the monthly average) represent the sum of the average monthly pumping rates for each well that was operating at the time the weekly flow readings were taken. Therefore, the maximum and minimum monthly flows are derived from only four or five weekly readings, and are not necessarily representative of the actual maximum and minimum flow that occurred in the month.

The average monthly flows shown in Tables 1.0 and 1.1 represent the monthly pumpage volume for each well field divided by the number of days in the month.

In some cases, the monthly averages shown are less than the monthly minimum flows or greater than the monthly maximum flows. This is because the monthly minimum and maximum is derived from only four or five weekly readings and is not the actual monthly minimum or maximum. The monthly average shown in the tables is a true average.

In some other cases the maximum, minimum and average monthly flows are similar. This indicates that in these instances the same wells in a well field were run almost continuously for the whole month.

It should be noted that in 1986 the Region's well field SCADA system became fully operational. The Greenbrook operator can now obtain instantaneous pumping rates at a number of well sites in the Kitchener system, but not all. For example, the Woolner well flow meters are tied into SCADA, but the Strange Street and Mannheim wells are not.

The SCADA system also records well status (on or off) on an hourly basis and tabulates the monthly pumping hours for each well.

B.2 Validity of Flow Records

The validity of the monthly maximum and minimum well field flows shown in Tables 1.0 and 1.1 are suspect because they represent only four or five daily readings in a given month. The validity would increase as the frequency of meter readings increase, e.g. instead of once per week as is current practice document well status on a daily basis. We note that this is currently possible with the new SCADA system.

The validity of the monthly average well field flow records depends on the accuracy of the well flow meters and on the accuracy in tracking the monthly hours of operation for each well.

The flow measuring devices used at the Strange Street, Mannheim and Woolner well fields include mostly Rockwell propeller meters and an orifice plate meter at Mannheim well K21. The Rockwell propeller meters range in size from 75 mm to 200 mm with flow ranges set according to line sizes. A high degree of meter accuracy normally requires a straight pipe length of 10 diameters upstream and 5 diameters downstream. Generally, this is not the case at the wells under consideration. The upstream straight pipe length is about 4 to 6 diameters, and the downstream straight pipe is often minimal, with either a valve or elbow just downstream of the meter. Under these conditions, the accuracy of the propeller meters could be in the 5% range, with the meter likely erring on the high side. However, the orifice meters installed under these conditions could not be considered an accurate measuring device.

The propeller meters are inspected and cleaned on an annual basis. Worn parts are replaced. If abnormal readings are encountered during the weekly well visit, the meter is inspected and repaired if necessary.

Prior to the SCADA system, the hours of operation for a given well in the Kitchener system were documented by the Greenbrook operator. The monthly summaries of well operating hours would be accurate, subject possibly to some human error.

The SCADA system has now eliminated the human error consideration in providing the monthly pumping hour totals for each well. However, SCADA records well status (on or off) on an hourly basis. This method of recording could lead to a sizeable error if well pumps are turned off and on quite frequently, e.g. if a well pump goes on just after SCADA records well status and shuts off just before the next hourly reading, the well operated for almost an hour yet was not recorded by SCADA. However, this should not be a problem as the operating bands for the Kitchener wells are sufficiently large that wells do not cycle too frequently. Hence, when a well pump starts up, it is operating for much longer than the one hour between SCADA status readings.

In summary, the propeller meters would appear to be providing flow measurement to an accuracy of about 5%, while the orifice meters cannot be considered a reliable measuring device. The regular meter inspection and repair program will ensure that the meters remain functional and accurate to within the error noted previously.

In conclusion, the validity of the monthly average flows for the Kitchener wells or well fields appears reasonable with the propeller meters recording pumpage volume and the SCADA system tabulating hours of operation.

B.3 Comparison of Flow Records

As discussed in Section A, previous studies have estimated the perennial yield and 7-day maximum capacity of the Strange Street, Mannheim East/West and Woolner well fields as:

Well Field	Perennial Yield ML/day	7-Day Maximum Capacity ML/day
Strange Street	9.1	15.4
Mannheim East/West	23.6	31.4
Woolner	10.0	10.8

Table 1.0 illustrates the following with respect to well field pumpage during the past four years.

Strange Street Well Field

The annual average (perennial) flows from the Strange Street well field were 8.05, 9.95, 9.84 and 10.66 ML/day in the years 1983, 1984, 1985 and 1986 respectively. Therefore, the well field was being pumped above its estimated perennial yield (9.1 ML/day) for the past three years. This may have resulted in a drop in ground water levels, or more likely occurred because the past three years were relatively wet with above-average precipitation and the well field could be pumped at a higher rate without ground water levels being seriously affected.

The maximum monthly well field pumping rate generally occurred in June or July over the past four years with the maximum occurring in November 1984 at 13.79 ML/day. This pumping rate is about 2 ML/day lower than the estimated maximum.

Mannheim East/West Well Field

The annual average flows from the Mannheim East/West well field were 23.92, 21.06, 22.49 and 22 34 ML/day in 1983 through 1986 respectively. These compare closely to the estimated perennial yield of 23.6 ML/day.

The maximum well field flows generally occur in the summer months during the peak demand period. The highest maximum flow over the past four years was 31.42 ML/day in July 1984. This pumping rate equals the predicted 7 day maximum capacity.

Woolner Induced Infiltration System

The annual average flows from the Woolner induced infiltration system were 5.69, 6.84, 6.04 and 7.56 ML/day in 1983 to 1986 respectively. Only well K82 was operating during the full four year period. Well K81 came on stream in early 1983 and well K80 began operating in July 1984. The well field has not yet reached its predicted perennial yield of 10 ML/day. One reason is that it has usually been shut down in June during the annual taste and odour episode.

The highest maximum flow in the last four years was 9.54 ML/day in June 1985. This pumping rate is about 1 ML/day less than the estimated 7 day maximum capacity.

C. WELL FIELD DISINFECTION

Table 3.0 appended summarizes the monthly chlorine dosage and chlorine residual information for the past four years at the Strange Street, Mannheim and Woolner well fields. Table 3.0 is completed for the wells at which chlorination is provided, i.e. Strange Street wells K10, K11 and K13, Mannheim well K21, and Woolner wells K80, K81 and K82.

Chlorination has always been provided at the Woolner wells because of the poor bacteriological quality of the raw well water (this is discussed further in Section 5.2). Chlorination was introduced at Strange Street wells K10 and K11 in August 1985, Strange Street well K13 in January 1986, and Mannheim well K21 in August 1986 in order to keep a chlorine residual in the Strange Street and Mannheim reservoirs which had experienced intermittent bacteriological contamination over the last few years (refer to Section 5.2).

Sodium hypochlorite solution (12% available chlorine) is the disinfectant used at the Strange Street and Mannheim wells. A mixture of sodium hypochlorite solution and granular sodium chlorite is used at the Woolner wells. The sodium chlorite is being used to combat a taste and odour problem with the river wells. Although the sodium chlorite has not eliminated the severe seasonal taste and odour problem, Region of Waterloo staff state that it has eliminated a persistent minor problem. The sodium chlorite to sodium hypochlorite solution mix is 10 kg/205 L drum (22 lbs. per 45 gal. drum).

Chlorine dosages and chlorine residuals are established for each well in order to provide the desired residual in the distribution system or ground storage reservoir. In the case of Woolner, the free chlorine residual aimed for at each well head is between 0.4 and 0.5 mg/L in order to obtain a 0.2 mg/L residual in the Kitchener distribution system on Heritage Drive. In the case of Strange Street and Mannheim, the free chlorine residuals at the well heads generally vary between 0.2 and 0.5 mg/L in order to provide a residual of 0.1 mg/L in the reservoirs.

Chlorine dosing is provided by manually adjusted chemical pumps at each well. The pump injection rate is set for the average well flow rate. Automatic flow pacing is not used. After the initial set-up, chlorine dosages are adjusted very little at the wells.

Two makes of chemical pumps are used at the wells: Liquid Metronics and Prominent. The pumps are of the positive displacement type and should accurately pump the selected rate. The pumps have a capacity range of 0 to 76 L/hr and maximum injection pressure between 150 and 250 psi. The chlorine pumps are inspected and calibrated at least once per year. This maintenance program ensures continued accuracy of the units.

Well head and reservoir chlorine residuals are usually measured once per week, but sometimes less often. The residuals are measured by Region staff using a portable HACH comparator. The test is performed by inserting a reagent into a chlorinated water sample and comparing it to a colour standard which will indicate level of chlorine residual. Although this test may be used to measure free and total residual chlorine, the Region only measures free residual. Combined chlorine (e.g. chloramines) is not measured. However, since there is very low ammonia levels in local ground water, chloramine levels should also be insignificant.

Sampling points for the chlorine residual test varies depending on the well. At the Woolner wells, a treated water line is provided that taps into the well discharge main about 15 m downstream of the point of chlorine injection. At Strange Street and Mannheim the water sample is taken from a tap located a few metres downstream of chlorine injection. Adequate chlorine mixing is likely achieved at all well sites.

Validity of the chlorine residual tests will depend on the accuracy of the test kit and colour standards, as well as operator ability to correctly match the colour of the test sample to the standard. The test kit used has an accuracy of 0.05 mg/L for the range encountered, i.e. less than 3 mg/L.

In summary, chlorine dosages at the municipal wells are adjusted only as needed in order to produce a residual in the distribution system or reservoir. The type of chlorine pump used, along with its annual maintenance, is considered reliable. The means of measuring chlorine residuals is reasonable given the range of residuals encountered.

D. WELL FIELD QUALITY

D.1 General Chemistry and Metals Analysis

Table 4.0 appended summarizes the annual maximum, minimum and average concentrations for the water quality parameters analyzed by the Region over the past four years at the Strange Street, Mannheim and Woolner well fields. Table 4.0 was tabulated for the wells and reservoirs that pump directly to the Kitchener distribution system, i.e. Strange Street Reservoir and wells K14 and K18, Mannheim Reservoir and Woolner wells K80, K81 and K82.

The information in Table 4.0 was obtained from Region of Waterloo water quality records. The Region currently measures 19 water quality parameters at each Kitchener well and reservoir twice per annum, typically in April and October. The parameters measured include:

Conductivity
Hardness
Calcium
Magnesium
Sodium
Potassium
Alkalinity
pH
Fluoride
Chloride
Sulphate
Silicates
Iron
Manganese
Phosphorus
Nitrogen Total Kjeldahl
Ammonium
Nitrates
DOC

All of the above water quality analyses are performed by the Region's laboratory, except for fluoride and DOC. The fluoride and DOC analysis are performed by the MOE lab. Where applicable, 'Standard Methods' as published by APHA, AWWA and WPCF are used in performing the water quality analyses.

Table 4.0 illustrates the following with respect to well field water quality over the past four years.

Strange Street Reservoir

Chloride levels show a possible increasing trend for wells K10, K11, K12, K13 and K17, which pump into the Strange Street Reservoir. However, historic maximum concentrations (90 mg/L) are well below MOE drinking water objectives.

The water is considered very hard with hardness levels of about 450 mg/L.

Nitrate levels are low (0.35 mg/L), well below the drinking water guideline.

The pH levels are within the desirable range for drinking water.

Sodium concentrations generally exceed 30 mg/L. Although there is no drinking water objective for this parameter, it is suggested in the Ontario Drinking Water Objectives (MOE, Revised 1983) that the Medical Officer of Health be notified if the sodium levels exceed 20 mg/L so that persons on sodium restricted diets can be made aware.

Iron levels are below the Province's maximum desirable concentration (MDC) of 0.3 mg/L and manganese levels are approximately equal to or exceed the MDC of 0.05 mg/L.

Strange Street Wells K14 and K18

Chloride levels show an increasing trend in both wells K14 and K18, but the increase has been more pronounced in the shallow well K18 over the past four years. The chloride levels are still well below the Province's MDC of 250 mg/L.

The well water is very hard with hardness levels between 350 and 400 mg/L.

Nitrate levels are low, well below the drinking water guidelines.

The pH levels are within the desirable range for drinking water.

Generally, the iron concentration in well K14 slightly exceeds the drinking water MDC, and the iron level in well K18 is well below the MDC of 0.3 mg/L. The manganese level in both wells exceeds the drinking water objective of 0.05 mg/L, especially in well K14 which is four times the limit.

Mannheim Reservoir

The Mannheim ground water supply can be considered very hard, with hardness levels exceeding 300 mg/L.

The nitrate levels range between 3 and 4 mg/L which is about one third of the Province's maximum acceptable concentration (MAC). No trend is evident with only two years of records.

The pH levels are within the desirable range for drinking water.

Both iron and manganese levels are well below the drinking water objectives.

Woolner Induced Infiltration System

The Woolner river well supply is considered very hard with hardness levels in the 250 to 300 mg/L range. However, this well field pumps water which is softer than the Kitchener well fields to the west, such as Strange Street and Mannheim. This is an indication that the Woolner wells capture the softer river water which has an average hardness of about 230 mg/L.

Maximum nitrate levels ranged from about 3.5 to over 5.0 mg/L in 1985 and 1986, approximately half the Provincial MAC of 10 mg/L. Grand River peak nitrate levels are about 6.0 mg/L.

The pH levels are within the desirable range for drinking water.

Iron concentrations are well below drinking water objectives, while manganese levels have exceeded the Province's MDC in 1985 and 1986.

D.2 Bacteriological Testing

Table 6.0 appended summarizes the monthly presence-absence (P/A) bacteriological testing for the years 1983 through 1986 for each well and reservoir in the Strange Street, Mannheim and Woolner well fields. Table 6.0 also summarizes monthly presence-absence testing at six points in the Kitchener distribution system, two supplied from each well field (refer to Figure 1 for the location of the distribution system sampling points)

The information in Table 6.0 was obtained from Region of Waterloo bacteriological testing records. The Region currently tests for bacteria on a weekly basis at each reservoir and well head that pumps directly into the Kitchener distribution system, and on a bi-weekly basis at each well head that pumps to a reservoir. The Kitchener PUC presently tests for bacteria on a weekly basis at about 30 locations in the Kitchener distribution system.

All of the presence-absence test analyses, both for the Region and Kitchener PUC, are performed by the MOE laboratory in Toronto. It is assumed that the Ministry lab follows their applicable standard method for presence-absence testing and that the bacteriological results are valid.

Both the Region and Kitchener PUC staff who collect the water samples for bacteriological testing use MOE 250 mL sterile glass bottles. The water samples are sent by overnight courier to the MOE laboratory.

The water samples for bacteriological testing are taken at the same well sampling points as the chlorine residual tests.

Table 6.0 illustrates the following with respect to well field bacteriological quality over the past four years.

Strange Street Well Field

Over the past four years, there has been no positive presence-absence test result for total or fecal coliform at wells K11, K12 and K13; only one positive P/A test for total coliform at well K18 two positive P/A tests at wells K14 and K17; and about one positive P/A test per year at well K10 prior to chlorination in 1985. The bacteriological quality of the well water is generally good.

There was fairly persistent bacteriological contamination of the Strange Street reservoir in 1984 and 1985, prior to the start-up of disinfection at wells K10 and K11 in August 1985. Since August 1985, there has been no indication of bacteria present in the reservoir.

Two bacteriological sampling points in the Kitchener distribution system are located in close proximity to the Strange Street ground water supply: Alice Avenue and Joseph Street. Since 1985, when the Kitchener PUC began bacteriological testing, there has been no positive fecal coliform P/A test at either sampling point and four positive total coliform P/A tests in 1986 at Alice Avenue, three in May and June, and five positive total coliform P/A tests in 1986 at Joseph Street, spread over a six month stretch of April through September.

These results suggest that there should be prudent use of disinfection during the hot weather months when positive P/A tests have occurred.

Mannheim East/West Well Field

Over the past four years there has been no positive presence-absence test results for total or fecal coliform at wells K21, K24, K25 and K26; only one positive P/A test for total coliforms at well K22 and three at well K23. Again, the bacteriological quality of the well water is good.

In 1985 and 1986 there was persistent bacteriological contamination in the Mannheim reservoir, prior to the start-up of chlorination at well K21 in September 1986 (chlorination facilities are provided at Well K25 as a back-up).

Two bacteriological sampling points are located in proximity to the Mannheim well field and probably obtain their water supply from Mannheim: McGarry/Fischer and Elmsdale Drive. Since 1985 there has been no positive fecal coliform P/A test results at either sampling point, but there was a three month stretch in 1985 (July through September) when five of 11 total coliform P/A tests were positive at Elmsdale, including three weekly samples in a row. A positive P/A test also occurred in May 1986. Also in July and August 1986 there were three of eight positive P/A tests for total coliforms at McGarry/Fischer. Other positive samples were found at McGarry/Fischer in March 1986 and October and November 1985.

These results also suggest the prudent use of disinfection in the summer months.

Woolner Induced Infiltration System

For the four years of bacteriological testing data at the Woolner wells there has not been any positive P/A test results for total or fecal coliforms in the disinfected water at well K82; four positive P/A tests for total coliform at well K80 (well began operating in mid-1984); and two positive tests for fecal and total coliform in September 1986 and a positive test for total coliform in August 1986 at well K81. Generally, the treated water quality is good.

The bacteriological quality of the Woolner raw well water is less desireable than the other well fields studied indicating contamination from the Grand River. It is interesting to note that the bacteriological quality of the raw water at wells K80 and K81 appears worse than at well K82, suggesting that more river water is pumped from K80 and K81. These two wells are also the source of the taste and odour problem in the Woolner well field.

Two distribution system bacteriological sampling points are located just northwest of the Woolner field and obtain their water supply from the three induced infiltration well fields. The sampling points are the Stanley Park Public School and the Grand River Arena. Since 1985 there has been no positive P/A test at the Grand River Arena, and three positive total coliform tests and one positive fecal coliform test at the Public School.

D.3 Water Quality Problems

There are currently two documented water quality problems at two of the three well fields under consideration in this study. Very low levels of trichloroethylene (TCE) were found in the Strange Street well K12 in 1986. The well was temporarily shut down. A taste and odour episode has occurred at the Woolner well field in May/June of four of the five past years. The wells are temporarily shut down or pumped to waste during the occurrence of taste and odour problems which sometimes extends into July or August.

Strange Street Well K12

In July 1986, trichloroethylene was detected at two private wells in Waterloo, just north of the Kitchener Strange Street well field and west of the Waterloo William Street well field. TCE levels were in the 30-70 ppb range which indicated a significant source of contamination in the vicinity of the private wells. As a result, the Ministry of the Environment sampled the Region's municipal wells in the area for volatile organics, including TCE.

In August 1986, MOE informed the Region that TCE contamination had been detected in Strange Street well K12. The MOE analyses indicated that a TCE level of 3 ppb was detected at K12 in a sample collected on 8 August 1986. As a precautionary measure, the Region shut the well down.

In three separate water samples taken from well K12 (8, 11 and 12 August 1986), the Ministry found TCE levels of 3.0 ppb. The detection limit of the analyses is 0.1 ppb.

On 12, 25 and 26 August 1986, the Region had their own Consultant take confirmatory samples at well K12, of which the 12 and 25 August samples were collected in duplicate for MOE analyses as well. All of the analyses of the samples collected by the Region's Consultant and analyzed by a private lab indicated no detection of TCE. The sample results from the MOE lab (including analysis of the duplicate samples) indicated a TCE level of 3.0 ppb.

The Region's Consultant concluded that even if the MOE sample results were representative, the TCE concentration is still an order-of-magnitude below the MOE interim drinking water objective of 30 ppb TCE. The Consultant recommended that well K12 be put back into operation with regular quality monitoring. The well is now back in operation.

Woolner Induced Infiltration System

In four of the last five years (1982, 1984, 1985 and 1986) taste and odour problems have occurred in the Kitchener infiltration wells, including the Woolner well field, making the supply from these wells unreliable at a period of time (May/June) when system water demands are approaching their annual peak.

In May/June 1986, the Region, with the assistance of a Consultant, M.M. Dillon Limited, carried out a series of water quality screening tests at the Woolner well field in an attempt to identify the cause of taste and odour. The range of parameters tested for was developed from a literature review of possible causes of taste and odour. A Flavour Panel was established to objectively identify the onset of a poor taste and odour episode.

The Flavour Panel provided a qualitative and semi-quantitative description of the taste and odour of the water samples. The Region's Panel only assessed water odour. The Panel was made up of a minimum of four Region staff who were preselected and screened for sensitivity to odour assessment. The panelists were trained before undertaking the odour tests.

A taste and odour episode was noted on or about 19 June 1986 by the Flavour Panel in the Woolner well field (Wells K80 and K81). The odour was of an earthy-musty type. Just before the onset of the odour episode, increased algae growth was noted in the river opposite the affected wells. Coincidentally, increased levels of nutrients were observed in the river. The evidence suggests that the taste and odour problem arises from bacteria metabolites produced when the bacteria feed on decaying algae in the river.

A few simple batch tests used to simulate ozonation and carbon filtration as remedial measures for the 1986 odour problem proved ineffective. A description of the tests follows:

- Ozonation treatment was simulated by using hydrogen peroxide. This provided an oxidyzing medium with potential to react with the odour components. It was noted, however, that hydrogen peroxide does not necessarily duplicate the action of ozone.

  Water was taken from the samples used for odour assessment. The samples were then dosed with hydrogen peroxide equivalent to 0.5, 1.0 and 2.0 mg/L of ozone. They were held at 10°C for five minutes to simulate reaction in the distribution system then subjected to the Flavour Panel analysis.

- Activated carbon treatment was similarly simulated. Samples of water were dosed with 0.5 g/L and 1 g/L of powdered activated carbon, then assessed by the Flavour Panel.

The Consultant recommended that this result be re-evaluated using more rigorous testing as these two treatment methods hold the most promise for odour removal.

Other potential causes of taste and odour that were apparently excluded by the 1986 screening tests are:

- iron nuisance bacteria;
- sulphate reducing bacteria;
- industrial organics - both as discharged to the river or modified by bacteria;
- chlorination by-products.

From May through July 1987 the Region, again with the assistance of a M.M. Dillon Limited, carried out additional Flavour Panel and chemical analyses at the Woolner well field. The objective of the Flavour Panel was to detect the onset of a taste and odour event before the consumers were affected. The purpose of the chemical analysis was to confirm changes in certain parameters at the onset of a taste and odour episode in order to identify parameters that would indicate an event is about to occur. The parameters that were analyzed include: temperature, pH, dissolved oxygen, conductivity, sulphide, sulphate, chloride, alkalinity, TKN, phosphorus, nitrates, nitrites, ammonia, chlorophyll and metals.

Well K80 experienced a taste and odour problem in early June 1987 and was then pumped to waste. The problem was noticed by nearby consumers, but not picked up by the Flavour Panel. From the start of the 1987 study in May the Panel had noted a slight 'medicinal' odour in Well K80. In mid-June the Panel noticed that treated water from K80 was particularly offensive.

Well K81 developed a medicinal odour in late June, but at no time was it as noticeable as Well K80.

The 1987 study concluded that the best indicator for a potential odour event appears to be the condition of the river.

During both the 1986 and the 1987 studies the odour event occurred just as the green algae in the river began to die. Observing the river and using a Flavour Panel may be the most effective means of predicting an odour event before consumers are affected.

Future taste and odour studies should include a carbon filtration test at Woolner Well K80 to determine its effectiveness in treating the problem, although it is recognized that the cost of the treatment may be prohibitive for the short period of time that it would be required.

E. NEED FOR ADDITIONAL WELL FIELD DISINFECTION/ TREATMENT

This Section uses the disinfection and quality information provided in Sections C and D to assess the need for additional disinfection/treatment at the Strange Street, Mannheim East/West and Woolner well fields.

E.1 Need for Additional Well Field Disinfection, Control and Monitoring

The bacteriological test results in the reservoirs, at the well heads and in the distribution system over the past four years (Table 6.0) were used to assess the effectiveness of present disinfection methods at the Strange Street, Mannheim and Woolner well fields, as well as to determine the need for additional disinfection measures. The basis for this assessment was to ensure a water quality as described in the Ontario Drinking Water Objectives (MOE, Revised 1983).

The disinfection summary over the past four years for the three well fields (Table 3.0) was used to assess the need for additional control and monitoring of well field disinfection.

As reported previously, the Region of Waterloo presently takes weekly bacteriological samples at each reservoir and well head that pumps directly to the distribution system, and bi-weekly samples at each well head that pumps to a reservoir. The Ontario Drinking Water Objectives (MOE, Revised 1983) requires a sampling frequency of more than weekly for a city the size of Kitchener that treats ground water.

Strange Street Well Field

Of the seven wells that make up the Strange Street well field, two wells (K14 and K18) pump directly into the Kitchener distribution system, and the remaining five wells (K10, K11, K12, K13 and K17) pump to the 9 ML (2 mg) Strange Street reservoir. Of the wells which pump to the reservoir, wells K10, K11 and K13 (maximum total capacity of 8.8 ML/day) are chlorinated, and wells K12 and K17 (maximum total capacity of 1.3 ML/day) are not. Both wells K14 and K18 are not currently chlorinated.

In the four years of bacteriological test results for the two wells which pump directly to the distribution system, only one sample of 194 was positive for total coliforms at well K18 and two samples of 164 were positive for total coliforms at well K14. The positive samples at each well were isolated events that may have been the result of sample contamination.

Based on the good bacteriological quality of the well water in K14 and K18, there does not appear to be a need to disinfect these two municipal sources. However, this should be confirmed with standard plate count (SPC) analyses.

Since the introduction of chlorination at wells K10, K11 and K13 which pump to the Strange Street reservoir, there has been no detection of coliform organisms in the reservoir. Prior to that time, detection of total coliform bacteria was a common occurrence. Therefore, there is a demonstrated need to chlorinate to control bacterial growth in the reservoir.

However, the disinfection summary for the past two years for wells K10, K11 and K13 show a wide variability in chlorine dosage and residual at the three wells (especially well K10), and a number of months when chlorine residual readings were not taken at the well head or in the reservoir, or apper to be mistaken readings.

The reason for the chlorine dosage and residual variability may be because the reservoir is supplied by three wells which are chlorinated and two which are not. All wells do not run at all times. Therefore, to maintain a constant chlorine residual in the reservoir, the chlorine dosage at the three wells that chlorinate (and hence chlorine residual) must be adjusted to match the well combination in use. This adjustment of chlorine dosages at each well requires operator time.

In order to avoid having to manually adjust chlorine dosages at the three wells in order to maintain a constant residual in the reservoir, it is recommended that the remaining two wells feeding the reservoir also be equipped with chlorination facilities. With all five wells chlorinated to the required residual, there will be no need for adjusting dosages when the number of wells that are on or off changes. This will ensure better control of the chlorine residual in the Strange Street reservoir.

An alternative to adding chlorination facilities to Wells K12 and K17 is to abandon well head chlorination and install a flow paced chlorine facility at the inlet to the Strange Street Reservoir. Therefore, instead of maintaining five well head chlorination units, only one would be required.

The monitoring of chlorine residuals at the Strange Street wells and reservoir can best be described as sporadic. Chlorine residuals should be monitored at least on a weekly basis at the wells and at the reservoir as done at the Woolner well field, but more preferably on a daily basis. This will ensure that sufficient chlorine is being added to maintain the minimum residual in the reservoir, or to make sure that excessive amounts of chlorine are not being added which may result in taste and odour complaints. The chlorine dosing pumps should be checked at the same time to ensure proper operation.

An alternative to manually monitoring chlorine residuals, as is present practice, would be to install chlorine residual analyzers. An analyzer could be installed at the Strange Street reservoir and tied into the Region's SCADA system. This could be a cost-effective option when considering staff time for manual monitoring seven days a week. It would also remove an opportunity for human error in monitoring chlorine residuals.

Because of the noted problems with the disinfection summary, it appears that there is no clear understanding of the disinfection process. It is recommended that clear goals be set for disinfection, a monitoring program initiated to meet these goals and staff be trained in the chlorination process.

Mannheim East/West Well Field

All six wells (K21 to K26) of the Mannheim well field pump to the 50 ML (11 mg) Mannheim reservoir. Only well K21 is presently chlorinated to provide a 0.1 mg/L residual in the reservoir, but well K25 is available as a back-up if well K21 is down.

The transmission mains connecting the Mannheim wells to the reservoir have service connections, except for K21. In the four years of bacteriological test results for the Mannheim wells, there has been no positive samples for total or fecal coliforms at wells K21, K24, K25 and K26; only one sample of 131 was positive for total coliforms at well K22; and three samples of 135 were positive for total coliforms at well K23. The positive samples at wells K22 and K23 were isolated events that may have been the result of sample contamination.

Based on the good bacteriological quality of the well water from the Mannheim wells there does not appear to be a need to disinfect at the well head, but because of the number of service connections that presently exist on the well field transmission lines, chlorination is recommended.

In 1985 and 1986, prior to chlorination of well K21, there was a persistent bacteriological problem in the Mannheim reservoir (23 of 87 samples were positive for total coliforms). Since September 1986 when chlorination began at K21, there has been one positive sample (of 12 samples) for total coliforms in the reservoir. Therefore, there is a demonstrated need for disinfection to control bacterial growths in the reservoir.

Noting that the Mannheim reservoir is a key supply for Kitchener-Waterloo, it is important to ensure that a chlorine residual exists in the reservoir at all times, i.e. when wells K21 and even K25 are off. Therefore, it is recommended that chlorination be provided at the reservoir inlet, as opposed to one or two wells in the well field, to ensure continuous disinfection.

Because of the high flows through the Mannheim reservoir there is a long-term cost benefit in using gas chlorination as opposed to sodium hypochlorite at the reservoir inlet. This assumes a 0.5 mg/L chlorine dosage to produce a 0.1 mg/L chlorine residual in the reservoir. However, it is recommended to continue with the use of sodium hypochlorite (in bulk storage) because it is used elsewhere in the system and because chlorine gas presents a greater safety hazard requiring a higher level of operator expertise.

Chlorination at the Mannheim reservoir inlet would require a small building to house the facilities. Also, there may be a need to flow-pace the chlorine injection. This would require installation of an orifice meter at the reservoir inlet that would measure inflow and pass an electrical signal to the chlorine metering pump which would automatically adjust chlorine dosage based on reservoir inflow. Alternatively, because the wells supplying the Mannheim reservoir are usually run constantly on a 24 hour basis, reservoir inflow would generally be constant and a manually adjusted chlorine metering pump may be all that is required.

It should be noted that the Region may choose not to install chlorination facilities at the reservoir inlet and continue chlorinating the Mannheim reservoir with well K21 until the Mannheim water treatment plant is operating in 1991. At that time, the water treatment plant will then be supplying chlorinated surface water to the Mannheim reservoir which will be blended with the existing ground water supplies to produce a chlorine residual in the reservoir. Chlorination could be discontinued at well K21 at that time.

It is also noted that since there are a number of service connections on the Mannheim well field transmission mains (mostly in Wilmot Township) and that distribution system disinfection is being recommended in Kitchener (refer to next page), the Region should strongly consider chlorinating all Mannheim wells.

It is also recommended that chlorine residuals be monitored at well K21, well K25 (when chlorinating) and in the Mannheim reservoir on at least a weekly basis, and more preferably daily. A chlorine residual analyzer tied into SCADA may be a preferred alternative to manually monitoring chlorine residuals.

Finally, the Region should develop clear goals, a monitoring program and a staff training program for chlorination.

Woolner Induced Infiltration System

The three Woolner wells (K80, K81 and K82) produce water of poor bacteriological quality and therefore are disinfected. The wells pump directly to the Kitchener distribution system.

In the four years of bacteriological test results at the Woolner wells there has been no positive samples for total or fecal coliforms in the disinfected water at well K82; four samples in 89 were positive for total coliforms at well K80;

and two samples of 168 were positive for fecal coliforms and three samples of 168 were positive for total coliforms at well K81. The positive samples in the chlorinated water at K80 and K81 were isolated events for the most part and may have been the result of sample contamination. However, it is noted that there were two positive weekly tests for both fecal and total coliforms in well K81 in September 1986.

The bacteriological test results at Woolner do not suggest the need for additional disinfection measures. However, because of the poor bacteriological quality of the raw well water, it is important to continue close monitoring of chlorine residuals at the well head and in the distribution system and it is recommended that the residuals be checked daily. Again, as an option to manual monitoring, a chlorine residual analyzer in the distribution system may be a cost-effective measure.

The four year disinfection summary for this well field shows good chlorine dosage control at all three wells.

Kitchener Distribution System

At present the Kitchener distribution system is not disinfected. Chlorine residuals are only provided in some supply reservoirs, notably Strange Street and Mannheim, and in the transmission mains connecting the Grand River induced infiltration wells to the Kitchener distribution system.

The City of Kitchener currently takes weekly bacteriological samples at about 30 locations in the distribution system. Over the past two years, positive bacteriological samples have generally been for total coliforms and were usually isolated events with the occasional occurrence of a number of positive samples over a two to three month period at a sampling point. It has been reported by the City of Kitchener that the initial positive bacteriological sample results in the distribution system are usually related to sampling error and show negative when re-sampled It has also been reported by the MOE Cambridge District Office that the positive bacteriological sample results can, in some cases, be attributed to where the samples are taken and how they are taken, not necessarily being representative of the bacteriological water quality in the distribution system.

However, it is recommended that all water in the Kitchener distribution system be disinfected. Chlorination, even to low residuals, would demonstrate that all reasonable precautions are being taken to ensure safe drinking water. The advantages of system chlorination include the suppression of bacterial growth in the distribution system and provide an opportunity to monitor for external contamination through loss of chlorine residual. The disadvantages of system chlorination include the added costs for facilities and chemicals and consumer disapproval of chlorination.

It is also recommended that:

- trained staff follow standard procedures in taking bacteriological samples in the distribution system to minimize sampling error;

- bacteriological sampling locations in the distribution system should be representative of actual water quality, e.g. sample at household taps, and should not necessarily be taken from the same points on each occasion;

- bacteriological testing should include periodic standard plate counts (SPC) to provide a better indication of bacteriological water quality in the distribution system.

As reported previously, the City of Kitchener presently takes weekly bacteriological samples at about 30 locations in the distribution system (approximately 120 samples per month). The Ontario Drinking Water Objectives (MOE, Revised 1983) requires that a municipality the size of Kitchener collect a minimum of 105 samples per month with a frequency of several times per week. The City appears to meet these requirements.

E.2 Need for Additional Well Field Treatment

The water quality summary over the past four years at the Strange Street, Mannheim and Woolner well fields (Table 5.0) and the reported water quality problems at the three well fields were used to assess the need for additional treatment and water quality monitoring.

Strange Street Well K14

The iron and manganese concentrations in Strange Street well K14 exceed the drinking water objectives of 0.3 mg/L and 0.05 mg/L respectively. High iron and manganese levels can cause staining of household fixtures and laundry, and cause taste and odour problems. The literature ("Taste as an Indicator for Drinking Water Quality", Journal AWWA, September 1980) states:

> "Among the metal ions in water, iron can be tasted in distilled water by the most sensitive 5 percent of the panel at 0.05 mg/L, ... manganese at 3.5 mg/L ..."

The above suggests the need for further evaluation to see if sequestering treatment is feasible at well K14.

It has also been reported by Region of Waterloo staff that water from well K14 has a slight hydrogen sulphide odour and the well is generally shut down except for the summer when system demands require its operation.

Strange Street Well K12

A trichloroethylene concentration of 3 ppb was detected in Strange Street well K12 in 1986. The well is now back in service because the TCE concentration was an order-of-magnitude below the MOE interim drinking water objective of 30 ppb. Well K12 should be added to the DWSP program so that its quality can be closely monitored

If the TCE levels in well K12 approach the MOE drinking water guideline or if it is desired to lower the present TCE concentration of 3 ppb to the detection limit, two treatment options are available: air stripping and granular activated carbon (GAC) adsorption. Either treatment method is applicable to this situation, but requires further evaluation based on capital and operating costs, and environmental impacts in order to select a preferred method.

Air stripping would require a tower of up to 8 m in height which must be enclosed for winter operation. This would create a visual impact in a built-up urban area. The air stripping tower cannot run under pressure, and hence re-pumping facilities would be required. The pumps and blowers required for air stripping would also create a noise impact.

Other than air stripping, adsorption is the only method available for removing organic compounds from drinking water. GAC or synthetic resins can be used in the treatment of well water for removal of organics. However, only GAC should be considered since synthetic resins are much more expensive. A GAC contactor can be run under pressure, and can therefore be a direct in-line installation with well K12, and not require re-pumping. Also, a GAC contactor is smaller in size than a comparable air stripping tower.

Woolner Induced Infiltration Wells

The seasonal taste and odour problem with the Woolner well field appears to be caused by bacteria metabolites produced when the bacteria feed on decaying algae in the river. GAC is the suggested method of treatment as it has been used successfully for the treatment of algae-related tastes and odours at MOE water treatment plants in Odessa and Desoronto. GAC bed life in this application has been in excess of five years with continuous operation.

However, a permanent GAC facility is probably too expensive and not practical for a seasonal taste and odour problem that only persists for one or two months each year. A portable trailer-mounted GAC contactor system may be more practical. It can be hooked up to the Woolner well K80 (and maybe K81) in June/July when the T&O problem occurs, and be available at other times of the year for treatment of other Regional wells that may require temporary removal of organics.

To be road transportable for use at a number of wells the GAC contactor tank diameter should be limited to 2.5 m. For a 900 L/min (200 gpm) facility, two contactors should be used in series, each 2 m deep. Both contactors could be mounted on one trailer. For larger treatment capabilities additional units would be used in parallel, e.g. a total capacity of 2700 L/min (600 gpm) would require three such trailer-mounted units.

During actual operation of this system the lead contactor would be exhausted first. At that time, the system should be shut down and the exhausted GAC replaced. On restarting, the second contactor (partially exhausted) would be piped as the lead contactor, ensuring maximum utilization of the carbon and final polishing of the effluent with the freshest carbon.

In switching the use of these portable GAC contactors from, for example, organic solvent removal (TCE) to T&O control or vice versa, it is recommended that the GAC be replaced. Desorption of the previously treated chemical can occur, contaminating the water being treated. It is also noted that the GAC bed life for T&O control will be much longer than for synthetic organics removal.

However, even portable GAC treatment may not be practical for the Woolner well field if other uses for the GAC facilities are not likely within the Region. Alternative solutions for the T&O problem include shutting down the Grand River wells during the seasonal T&O occurrence or to 'do nothing'. Well shutdown is usually not a viable alternative in June or July when peak water demands occur. The 'do nothing' alternative will create consumer complaints.

As noted in Section C, granular sodium chlorite is being mixed with sodium hypochlorite solution to combat the taste and odour problem in the river wells. Its use has not eliminated the seasonal taste and odour problem, but is reported to have removed a perennial minor problem.

The effectiveness of sodium chlorite in removing the taste and odour problem is questionable. The oxidation potential of the chlorite ion is less than the hypochlorite ion (and much lower than hypochlorous acid). Even if sodium chlorite was somewhat effective, it has other disadvantages as listed below:

- The Ontario Drinking Water Objectives state that "...the formation of chlorite in ... is reported to have detrimental, but poorly defined, health effects". The method of sodium chlorite use at the river wells ensures the presence of the chlorite ion in the well water.

- Sodium chlorite is an expensive chemical, costing perhaps three times as much as hypochlorite.

- Sodium chlorite is a hazardous chemical, normally stored in a separate, dry, cool room. It breaks down on contact with acid, producing sufficient heat and

> chlorine to sustain the reaction once started; it combines with organics (dust, clothing, etc.) producing explosive compounds; in a fire, chlorite generates its own oxygen (and chlorine) making conventional fire extinguishers and water ineffective.

In light of the above, it is recommended that the use of sodium chlorite at the river wells be discontinued.

Taste and odour control can be achieved by using activated carbon as discussed above.

F. NEED FOR AN EMERGENCY PLANNING PROGRAM

This Section uses the quality information provided in Section D to assess the need for an emergency planning program for the Kitchener ground water supplies. The program would be set up to ensure that the Kitchener aquifers continue to supply water of drinking water quality in the long-term. The program would include a ground water quality monitoring strategy, contaminant spill clean-up capability and finally, the ability for contaminant treatment at the well head.

F.1 Ground Water Quality Monitoring Strategy

The recent detection of very low levels of TCE in Strange Street well K12 is an indication that a more complete ground water quality monitoring program is required for the Kitchener water supplies. The monitoring strategy should be based upon a reasonable understanding of the hydrogeologic setting of the Kitchener aquifers and knowledge of the potential sources of contamination which could pollute the existing ground water supplies. Then a monitoring network and sampling program can be established.

There is already a reasonable understanding of the hydrogeologic setting in the Kitchener area as a number of extensive hydrogeologic studies have been completed (refer to Section A). There is, however, a need to locate and define the potential sources of ground water contamination.

A logical step-by-step approach should be followed to develop and implement a ground water monitoring network and sampling program which will provide reasonable assurance that any significant aquifer contamination is identified.

Realistically, it is not practical to continuously monitor for all possible pollutants in all aquifer systems, but the monitoring strategy should be thorough. Each Kitchener well field may have associated with it certain land uses distinct from others, and as such, a monitoring program should be designed accordingly.

As discussed above, the first step in developing the monitoring strategy is to develop a reasonable understanding of the hydrogeologic setting in the Kitchener area.

The second step is to undertake a land use survey to define the potential sources of contamination that exist within the capture areas of the Kitchener well fields, both area wide (non-point) and site specific (point) sources. This source inventory should not only include facilities currently in operation but past point source activities as well. The basic information required would include type of development, owner-operator, location, type(s) of hazardous chemicals used, manufactured or stored on-site, and quantities (in the case of agricultural non-point sources land application rates of chemicals).

The following discussion lists some potential non-point and point sources of contamination which could pollute the Kitchener aquifers and describes a program proposed to monitor these sources.

Non-Point Sources of Contamination

Non-point sources of contamination include area-wide chemical use and application which can result in the gradual accumulation of pollutants in the ground water system. A number of examples of non-point sources are:

- Road de-icing salt application.

- Components of sewage - pathogens, nitrates, metals and organics derived from sewage collection networks and storm sewer systems, including urban areas serviced with septic tank systems.

- Agricultural activities - long-term application of fertilizers (nitrates), soil fumigants (DBCP, EDB, aldicarb and other pesticides), chemigation (where chemicals are mixed with irrigation waters) and herbicides.

The effects of such area-wide activities are difficult to quantify due to the long periods of time involved in the migration and accumulation of common salts, metals and other inorganic and organic chemicals in the ground water environment. Biological degradation and physical adsorption processes alter or eliminate more reactive contaminants from ground water pathways, however, many highly soluble products have been identified in aquifer systems.

Area-wide non-point source contaminants should be monitored via routine sampling and analysis at each municipal well head or reservoir which pump directly to the distribution system. The monitoring program must address the detection of potential contaminants in a way that is comprehensive enough and timely enough to protect the consumers in Kitchener. In developing the monitoring program, two questions should be considered.

- What chemicals should be monitored?
- What concentration criterion should be used for triggering action?

There are various documents which list chemicals that should be monitored for safe drinking water. The list that would appear most applicable to the Kitchener situation is the 140 parameters in the Ontario Drinking Water Surveillance Program (DWSP). The list is included in Appendix C.

Generally, the chemicals on the list are of a human health concern or are aesthetically displeasing. It is noteworthy that some parameters listed are not particularly related to health or aesthetics, but are included to characterize general water chemistry. Most parameters related to general water chemistry are currently analyzed for at the Kitchener well heads twice yearly. These are useful long-term indicators of water quality.

The basis for the non-point source monitoring strategy is to detect long-term degradation of the Kitchener ground water supplies rather than detecting short-term point source events. This approach is made secure in the following two ways:

- Undertake remedial measures when the DWSP analysis show that an Ontario Drinking Water Objective is being exceeded. (The ODWOs only cover about 40 parameters of the 140 analyzed for on the DWSP list. Other drinking water guidelines, e.g. World Health Organization and USEPA, can be used to judge water quality.)

- Schedule the frequency of sampling and parameter analyses to reflect water quality trends and aquifer vulnerability.

For the first year the sampling should be done every two months in order to establish a data base (as is currently being proposed in the DWSP for Kitchener). After the first year the following schedule is suggested·

- for sample points where no contaminants are detected in an area considered to be an invulnerable supply - every three years;

- for vulnerable ground water supplies with no previous contaminant detection - every year;

- where contaminants are detected - sampling should be quarterly.

The criterion of vulnerability should consider aquifer hydrogeology and location relative to population centres and industrial activity.

Point Sources of Contamination

The identification of all point sources of contamination within the Kitchener area is not practical, nor necessary. Many sources may not be of significant quantity or of a particularly hazardous nature to warrant special attention. There are however, a number of land use activities known to have caused ground water contamination in other areas of Canada. A number of examples are:

- Bulk liquid product storage facilities including fuel, oil, gasoline and chemical products (e.g. agricultural chemicals).

- Road salt storage and snow stockpile locations.
- Municipal landfills.
- Industrial waste disposal facilities (liquid or solid; source of a variety of organic and inorganic wastes).
- Sewage disposal lagoons (source of pathogens, nitrates, cleaning solvents).
- Industrial operations (e.g. refineries, metal plating, etc.).
- Wood wastes (phenols, tannins and lignins).
- Abandoned quarry or aggregate operations where waste disposal has taken place.
- Feed lots (pathogens, nitrates).
- Railway yards (source of hydrocarbons and other chemicals resulting from spills).
- Abandoned wells - particularly those wells associated with past or current industrial activities. Wells that are improperly abandoned can become direct conduits to the municipal aquifers by-passing protective till layers.

The above list of potential point sources of contamination is not all inclusive, but it serves as a guide to the types of activities that should be inventoried. A more complete list should be put together by Regional staff who are more familiar with the types of development within Kitchener. This is particularly important when considering past point source activities. Archive or municipal records of past industrial and waste disposal activities are of particular importance in the identification of significant potential sources of contamination. Old coal gasification plants are one example of past industrial activities that could result in ground water contamination.

Monitoring at the municipal well head is not a suitable mechanism for the assessment of point sources of contamination. Once a point source contaminant reaches the municipal aquifer and is picked up by a municipal well or well field, it may be too late for aquifer clean-up and restoration, depending on the type of contaminant and magnitude of the source.

The approach to point source monitoring is achieved through the implementation of a strategy which first inventories potential sources, and then develops and maintains communication links with the owner-operator of the identified sites. Therefore, if a spill or tank leak occurs it will be directly and quickly reported to the Region.

It is far too big and expensive a task to expect the Region to monitor all the potential point sources of contamination in the Kitchener area. A mechanism should be put in place whereby the Region will first make the owner-operator of point source facilities aware of the existing Kitchener ground water supply and how their facility may impact on it. Then the Region should receive assurances from the owner-operator that their operations will be conducted in a sound environmental manner with the knowledge that if operated improperly, their facilities could contaminate the Kitchener water supply. These assurances can be provided in a number of ways, but good communication links between the owner-operator and the Region is a practical first step.

Therefore, the owner-operator will be responsible for notifying the Region if a spill or leak takes place on his premises.

For the more significant potential sources of contamination, site-specific surface and ground water monitoring may be required on the part of the owner-operator to ensure that the operator does not contaminate the ground water system. A voluntary, cooperative program between the Region and the owner-operator of certain facilities may provide an acceptable level of protection for the existing municipal aquifers.

The Region and City of Kitchener should also set an example for private industry in monitoring and managing their own point and non-point sources of contamination. For example, the amount of de-icing salt applied to roadways, the selection of snow disposal sites, salt stockpile locations, location and design of municipal landfills, and bulk fuel facilities represent the types of activities which require proper management and monitoring

F.2 Capability for Contaminant Spill Clean-Up

Monitoring potential non-point and point sources of contamination within the capture areas of the Kitchener well fields is one line of defence to ensure the long-term viability of the Kitchener ground water supplies. A second line of defence is a contaminant spill reporting network and a contaminant spill clean-up capability within the Region. These already exist within the Region and will be described below.

Transport of Hazardous Goods

Under the Federal Transportation of Dangerous Goods Act (TDGA) and Provincial Dangerous Goods Transportation Act all hazardous materials and wastes must be documented and labelled during transport. As well, all transport vehicle operators must be trained to take appropriate actions, including reporting, in the event of a transportation accident. These regulatory requirements help greatly in quick response to contaminant spills because they quickly identify the hazardous material and require notification of appropriate authorities for spill response and clean-up.

These regulations apply only to transport of hazardous materials. There are now similar requirements being implemented for labelling hazardous materials at industrial facilities. The Workplace Hazardous Materials Information System (WHMIS) directive is currently being implemented and will require that by 31 October 1988 all hazardous materials in the workplace be labelled. Therefore, at the present time, there is a possibility that the identity of spilled material at an industrial plant may not be known and delay spill response efforts.

Contaminant Spill Reporting

Under the TDGA regulations, transport spills must be reported to:

- local police and/or fire department as required;
- Ministry of the Environment; and
- authorized spill response personnel for the transport company and/or hazardous material owner.

As well, under the Ontario Spills Bill (Part ix of the Environmental Protection Act) all pollutant spills that can impair the environment must be reported to the MOE and the regional municipality.

The Ministry has a 24 hour toll-free spill reporting telephone number at their Spills Action Centre in Toronto. MOE will document spill information and ensure that all other authorities are contacted, and will enquire as to what response measures are being taken and by whom. The Spills Action Centre will not normally recommend procedures to be taken during a spill clean-up. They will, however, provide clean-up information if absolutely necessary to ensure that the environment is not impaired. The Ministry will often send one of their regional personnel to a spill site to supervise or monitor the spill response and clean-up.

Another important spill reporting mechanism has been set up by the Region of Waterloo. The Region has a five person spill response team that can react to a spill emergency on a 24 hour basis. The Regional fire and police departments have been trained to contact the Region's spill response team in the event of a spill occurrence. The spill response team can be contacted on a 24 hour basis at the Greenbrook Pumping Station in Kitchener or directly during normal business hours. If the water supply operator at Greenbrook receives a spill report, he will notify the on-call member of the Region's spill response team. The response team member will go immediately to the spill site to assess the situation. As well, he will notify the MOE and local municipality about the spill occurrence.

Spill Response and Clean-up Capability

The most comprehensive spill response capability in the Kitchener area is that of the Region of Waterloo. As stated above, the Region has a five person spill response team who visit all reported spill occurrences, and have the capability for spill clean-up if necessary.

The Region has a "Contingency Plan for Oil and Hazardous Material Spills" which lists the local response personnel depending on the spill type and location; municipal equipment available for spill clean-up; federal and provincial contacts; petroleum company contacts; and a method of spill classification for reporting purposes.

The Region's spill response team is trained in methods to clean up oil and hazardous material spills. The Region's response team generally reacts to spill occurrences in the following manner:

- prefer to act as advisors and have the transport company or owner of the hazardous material conduct the clean-up;

- however, if a spill is not being cleaned up quickly enough or in the proper manner, then the Region's response team will conduct the clean-up. The Region will bill the responsible parties for the clean-up costs;

- generally, if the Ministry is present at a spill site, the Region will take a 'back seat' and respond to the Ministry's requests.

The Region has access to all Regional and municipal vehicles, equipment, etc. for spill response. As well, the Region keeps a list of private equipment and material suppliers, including waste management companies, that will respond quickly, if required.

The Region's spill response team is trained in all aspects of response and clean-up. They stress worker safety as a first priority followed by quick action to ensure that the contaminant is cleaned up as quickly as possible in order to minimize environmental impacts. The response team is especially aware of the potential for contaminating the Region's ground water supplies and all contaminated soil is removed from a spill site to avoid aquifer contamination.

The above discussion demonstrates that procedures are in place for contaminant spill reporting in the Kitchener area, and that the Region has a strategy and procedure for spill response and clean-up. Therefore, the spill response and clean-up capability in the Region is considered adequate for aquifer protection for spills that are reported.

F.3 Emergency Treatment of Polluted Aquifers

The last line of defence in an emergency planning program for the Kitchener ground water supplies is to remove an aquifer contaminant at the well head. This measure, hopefully, will never have to be carried out. The ground water quality monitoring strategy, and spill response and clean-up capability should identify potential aquifer contamination before it becomes serious and allow implementation of remedial and clean-up measures.

However, if a Kitchener aquifer does become polluted, there are treatment options available for contaminant removal in order to keep a well or well field in operation. The potential point and non-point sources of contamination listed in Section F.1 could pollute the Kitchener aquifers with one or more of the following contaminant "classes".

- acids (e.g. sulphuric acid);
- bases (e.g. liquid ammonia);
- agricultural chemicals (e.g. pesticides);
- heavy metals (cadmium, lead, chromium, mercury);
- petroleum products (gasoline, fuel oils);
- organic solvents (TCE);
- organic chemicals (PCB).

There is no single treatment process that could be successfully applied to all of the above. Treatment options applicable to well head removal of contaminants are discussed below.

Acids or Bases

Movement of acids through the ground could promote leaching of metals and other contaminants from the soil. However, ignoring the effects of leaching, acids can be neutralized at the well head using caustic soda, soda ash or lime. Equipment required would be a chemical mixing tank and metering pump with feed paced by a downstream pH probe.

Ammonia can be removed from the well water by air stripping. This form of treatment was discussed in Section E.2. Alternatively, ammonia can be removed by superchlorination with the excess chlorine removed chemically with sodium bisulphite or sulphur dioxide.

Pesticides

Pesticides can be removed by GAC adsorption as discussed in Section E.2.

Heavy Metals

Heavy metals (e.g. cadmium, lead, chromium, mercury, etc.) would require treatment by ferric sulphate coagulation or lime softening followed by sedimentation and filtration. This is considered impractical on a well by well basis.

Petroleum Products

Gasoline or fuel oils are difficult to treat. While GAC may remove most of the fuel oil, there will probably be a residual taste and odour as it has a low T&O threshold.

Organic Solvents

Organic solvents such as TCE, can be treated with air stripping or carbon adsorption as discussed previously.

Organic Chemicals

Organic chemicals (e.g. PCBs) can be removed with a GAC contactor.

G. SUMMARY OF MODIFICATIONS FOR THE KITCHENER GROUND WATER SUPPLIES

This Section summarizes the needs for additional disinfection, treatment and emergency planning procedures for the Kitchener ground water supplies. A preliminary schedule for the implementation of these needs is also given.

The needs are divided into two implementation time-frames:

- those requiring implementation over the short-term (e.g. within a year);
- those requiring implementation over the long-term (e.g., within 5 years);

G.1 Short-Term Modifications

The list of modification's requiring short-term implementation are as follows:

i) Well Field Disinfection

General

All Kitchener weekly bacteriological samples should be analyzed for standard plate counts for at least the next year and possibly two years. This will determine the overall bacteriological quality of the Kitchener water supply. Bacteriological background analyses should be done as well.

The Region should increase the bacteriological sampling frequency to more than weekly as per the Ontario Drinking Water Objectives.

The Region should develop a chlorination plan that sets clear goals, outlines a monitoring program and undertakes a staff training program.

Strange Street Well Field

Wells K12 and K17 should be equipped with chlorination equipment to ensure better control of chlorine residuals in the Strange Street reservoir (estimated cost is $7000 for sodium hypochlorite feed system). An alternative to equipping Wells K12 and K17 with chlorination equipment is to abandon well head chlorination and install a flow paced chlorine facility at the inlet of the Strange Street reservoir. Therefore, instead of maintaining five well head chlorination units, only one would be required.

Monitor chlorine residuals at the Strange Street wells and reservoir in a more consistent manner on at least a weekly basis, and more preferably on a daily basis. An alternative to manually monitoring chlorine residuals, as is currently done, would be to install chlorine residual analyzers. An analyzer could be installed at the Strange Street reservoir and tied into the Region's SCADA system. This could be a cost-effective option when considering staff time for manual monitoring seven days per week. It would also remove opportunity for human error.

Mannheim East/West Well Field

All Mannheim wells should be chlorinated because of the number of service connections that presently exist on the well field transmission mains.

Monitor chlorine residuals at well K21, Well K25 (when chlorinating) and the Mannheim reservoir on at least a weekly basis, with an eventual objective for daily monitoring. A chlorine residual analyzer tied into SCADA may be a preferred alternative to manually monitoring chlorine residuals.

Woolner Induced Infiltration System

Monitor chlorine residuals at the well heads and in the distribution system on a daily basis because of the poor bacteriological quality of the raw well water. Again, as an option to manual monitoring, a chlorine residual analyzer in the distribution system may be a cost-effective measure.

Kitchener Distribution System

It is recommended that all water in the Kitchener distribution system be disinfected. It is also recommended that:

- trained staff follow standard procedures in taking bacteriological samples from the distribution system in order to minimize sampling error;

- bacteriological sampling locations in the distribution system should be representative of actual water quality, e.g. sample at household taps, and should not necessarily be taken from the same points on each occasion;

- bacteriological testing should include periodic standard plate counts to provide a better indication of bacteriological water quality in the distribution system.

ii) Well Field Treatment

Woolner Induced Infiltration System

It is recommended that the use of sodium chlorite at the river wells be discontinued because of its questionable effectiveness in removing taste and odours, health risks, cost and hazardous nature.

The most effective means of identifying taste and odour events appear to be through the use of a Flavour Panel and observing algal growth in the river.

A field test at Well K80 should be carried out to determine the effectiveness of activated carbon in treating the seasonal taste and odour problem.

G.2 Long-Term Modifications

The list of modifications requiring long-term implementation are as follows:

i) Well Field Flow Records

Replace the existing orifice plate meters which measure well pumpage volumes with more accurate propeller-type meters.

Document well status on a daily basis, as opposed to weekly status now taken, so that monthly maximum and minimum well field flows are more accurate.

ii) Well Field Disinfection

General

The Region should continue with a program of installing treated water sample lines a sufficient distance downstream of chlorination addition at the well head (e.g. 27 pipe diameters).

A similar optimization study should be carried out for all Kitchener ground water sources.

Mannheim East/West Well Field

Subject to the construction schedule for the proposed Mannheim Water Treatment Plant, provide chlorination facilities at the inlet to the Mannheim reservoir to ensure continuous disinfection (estimated cost is $55,000 for sodium hypochlorite facilities). This would only be done if the individual Mannheim wells were not chlorinated.

Wilmot Township should implement a bacteriological sampling program in the Mannheim area where residents are supplied from the Mannheim well field.

iii) Well Field Treatment

Strange Street Well K14

Elevated iron and manganese levels (above Ontario drinking water objectives) suggests the need for sequestering treatment. This treatment method should be evaluated further to determine its feasibility at well K14.

Strange Street Well K12

Add Well K12 to the DWSP program for further monitoring.

Treatment is not required for present TCE concentrations. If TCE levels increase and approach drinking water guidelines the treatment options include air stripping and activated carbon adsorption.

Woolner Induced Infiltration System

Well K80, and to a lesser extent well K81, experience a seasonal taste and odour problem. Treatment could include GAC adsorption; however, a permanent or portable GAC unit is expensive and may not be justifiable for this problem only. The Region may attempt to get by without these wells during the annual June/July occurrence. This may be difficult from a supply standpoint until the Mannheim WTP is operational.

iv) Emergency Planning Program

Ground Water Quality Monitoring Strategy

There is a need for an expanded ground water quality monitoring program in Kitchener. The Ontario Drinking Water Surveillance Program, as currently being undertaken in Kitchener, will monitor for non-point sources of contamination. An inventory and monitoring programs for past and present point sources of contamination, as outlined in Section 7, is also proposed.

The Region and City of Kitchener should set an example for private industry in monitoring and managing their own potential point and non-point sources of contamination.

Contaminant Spill Clean-Up

Existing program(s) and policy appears adequate.

Emergency Treatment of Polluted Aquifers

Further investigations are required on the feasibility of portable, trailer-mounted treatment systems for treating contaminated well water.

APPENDIX A
DETAILED WORK PLAN

WATER PLANT OPTIMIZATION STUDY

OPTIMIZATION PROTOCOL INCLUDING GENERAL TERMS OF REFERENCE FOR THE PLANT CONSULTANT

Ontario Ministry of the Environment
Water Resources Branch
August 1986

06/04/87 (REV. 1)

WATER PLANT OPTIMIZATION STUDY

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Ministry of the Environment
Water Resources Branch
Drinking Water Section
1 St. Clair Avenue West
Toronto, Ontario
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Introduction

The information contained herein consists of a preamble and general terms of reference for the "Plant Consultant".

Basic Premise of the Water Plant Optimization Study

The majority of drinking water supply facilities in Ontario have treatment directed at microbiological disinfection and/or removal of suspended material.

The purpose of the Water Plant Optimization Study (WPOS) is to document and review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes.

The following items relate to the emphasis on particulate removal in a plant evaluation:

- Organic contaminants (dioxins, PAHs) are associated, at least in part, with particulates.
- Particulates themselves have health-related limits (turbidity/bacteria).
- In striving for excellence in water treatment, it is important to examine all possible approaches, but first optimum use should be made of the processes already in place.

The Drinking Water Surveillance Program (DWSP) is a continuously updated base of information on Ontario water plants and water quality. Appended herewith is a detailed description of the DWSP and the DWSP Questionnaire (Appendix A). In connection with the DWSP, a plant investigation and process evaluation study is required for each plant entering the program.

The Drinking Water Surveillance Program and the Water Plant Optimization Study are being co-ordinated for the following reasons:

- Some of the components of interest are the same, and cost savings can be realized.
- The DWSP should focus on plants which have been optimized and are producing the best possible water; documentation of plants which are known to be inefficient is non-productive.

WATER PLANT OPTIMIZATION STUDY
INTRODUCTION

General Information

1. Operator training and certification is an important component of plant optimization. Plans are already underway with the MOE/Municipal Engineers Association (MEA) to implement such a program.

2. The mechamism for ensuring ongoing optimization will be through an annual inspection by MOE staff or consultants, or a combination of the two.

3. The study has been organized with a team approach in mind; thus, progress reports and a meeting with the Project Committee are required as the work progresses.

4. It is not the intent of this study to provide a detailed implementation scheme for plant rehabilitation; however, it is necessary to scope the feasible short and long-term process modification, if required, to achieve optimum disinfection and contaminant removal.

5. All information provided in the study must conform to the Ministry's "Metrication Guidelines for Consulting Engineers", and existing information used for all designs, drawings, specifications, etc., for this project must also be converted into metric (SI) units.

Organization

On the following page is an organization chart which describes the various groups involved in each plant study.

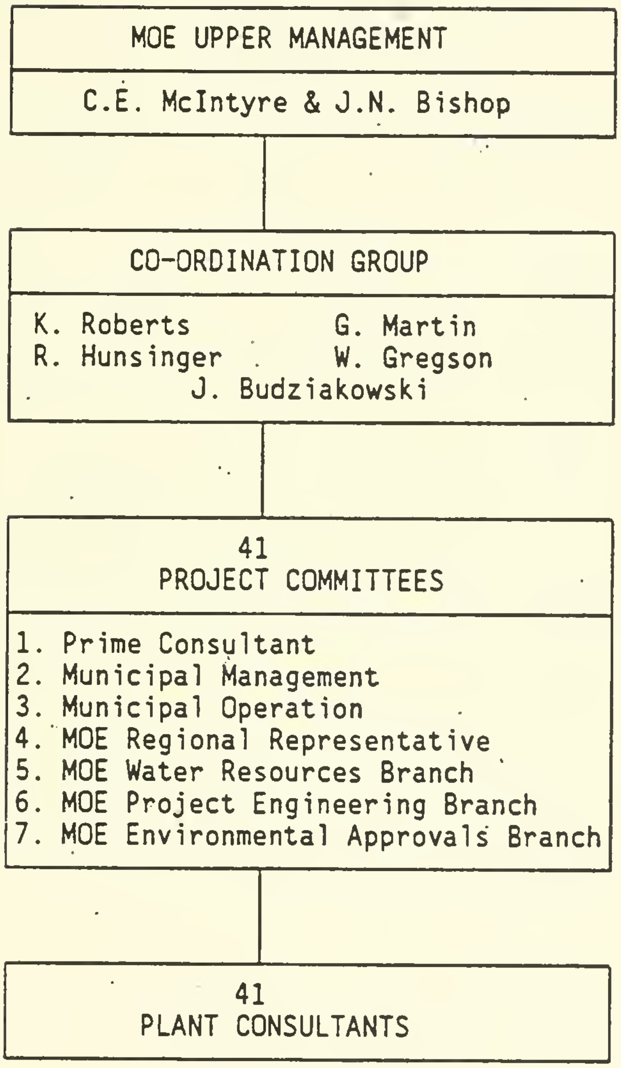
Project Committee

A "Project Committee" will be struck for each water plant. The "Project Committee" will consists of Municipal and MOE representatives and a "Prime Consultant". The "Project Committee" will formulate a set of specific terms of reference for the "Plant Consultant", using the "General Terms of Reference" contained herein as the basis. It is important that the same general approach be utilized for all plants; therefore, only some specific inclusions should be allowed in the plant specific terms of reference.

The "Project Committee" will direct the "Plant Consultant" in carrying out work described in the plant specific terms of reference. The "Project Committee" will also review the progress of the work and evaluate the final report.

WATER PLANT OPTIMIZATION STUDY

Reporting & Co-ordination



Prime Consultant

The "Prime Consultant" for the study will co-ordinate all of the water plant optimization studies by carrying out such tasks as:

- Setting up project committees
- Participate in development of the specific terms of reference for each plant
- Liaison with "Plant Consultants" regarding progress reports, meetings, and final reports.
- Preparation of a report summarizing the results of the 41 plant studies.

Plant Consultant

The "Plant Consultant" will carry out the data gathering, interpretating and recommendation steps outlined in Tasks 1 through 8.

The "Plant Consultant" must provide staff with extensive experience in evaluation of existing water treatment facilities who will maintain direct involvement in all phases of the project.

Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

Work Tasks

1. Receive an information package from the MOE. Review the information provided and meet with the MOE staff, if required, to discuss the project.

2. Document the quality and quantity of raw and treated waters.

3. Define the present treatment processes and operating procedures. Prepare a progress report on Works Tasks 1-3 for the Project Committee.

4. Assess the methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant.

5. Assess current disinfection practices and possible improvement methods.

6. Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal.

7. Prepare a draft report for the project committee's review.

8. Prepare the final report.

1. RECEIVE AN INFORMATION PACKAGE FROM THE MOE. REVIEW THE INFORMATION PROVIDED AND MEET WITH THE MOE STAFF, IF REQUIRED, TO DISCUSS THE PROJECT.

Elements of Work

(a) Receive an information package from the MOE concerning the plant and the study. This package includes a general terms of reference, a general table of contents for organizing the study in a manner consistent with other plant reports, the WPOS reporting tables and a copy of Ontario Drinking Water Objectives.

(b) Review the information and prepare for a meeting to initiate the work on the project, including preparation of a schedule of manpower and staff committments.

(c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule. If a consultant is carrying out more that one study it may not be necessary to meet with the MOE at the start of each study.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS.

Elements of Work

(a) Prepare a monthly summary of maximum, minimum, and average flows for the last three consecutive years (Table 1.0). Address any discrepancies which exist between raw and treated flow rates.

(b) Based on the above, briefly review and tabulate for the last three years, the monthly maximum, minimum, and average per capita flow for the total population served by the plant (Table 1.1). Compare the plant data with typical per capita flows for the local region. Indicate major consumers who may influence the figures.

(c) Document the methods of measuring the raw and treated water flow rates.

(d) Summarize, for the last three consecutive years, where available, the raw and treated water; turbidity, colour, residual aluminum/iron, pH, temperature and treatment chemical dosages (other than disinfection and fluoridation). The summary should indicate the monthly daily average and maximum and minimum day (Table 2.0).

For the same three year period, tabulate also the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with particulate removal occurred (Tables 2). Document enough data to define and evaluate those problems.

Record other data, such as particulate counting, suspended solids, and algae counting (Table 5.0) which could reflect on particulate removal efficiency.

Document the source and methods used in determining all information.

A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(e) Summarize for the last three consecutive years, where available, the disinfectant demand, dosages (including all disinfection related chemicals and residuals) for all application points as well as fluoridation dosage and residual. The summary should indicate the monthly daily average and maximum and minimum day (Table 3.0).

For the same three year period, tabulate (Tables 3) the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with chlorine residuals and/or positive bacterial tests identified in Table 6. Document enough data to define and evaluate those problems.

Document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(f) Prepare a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information (Table 4). Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information.

Document the source and methods used in determining all water quality information and establish the validity of the data, comparing plant and outside laboratory data.

(g) Tabulate, for the last three consecutive years, the raw and treated water bacterial test information at the plant (Table 6).

Document the source and methods used for all data provided.

(h) Document the water sampling systems (source, pump, line-material and size, vertical rise velocity sampling location) used in the plant (similar to DWSP Questionnaire in Appendix A).

(i) Prepare a summary of inplant testing including Test, Sampling Point, Testing Frequency, Reporting Frequency, Testing Instrumentation including calibration.

(j) Identify other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

3. DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. PREPARE A PROGRESS REPORT ON WORK TASKS 1-3 (8 COPIES), FOR THE PROJECT COMMITTEE.

Elements of Work

(a) Where drawings are available, assemble sufficient record drawings of a reduced size, to document the general site layout and the interrelationship of major plant components. If available, include a process and piping diagram (PAPD) of the plant operations.

(b) Prepare a simplified block schematic of all major plant components including chemical systems and indicating design parameters. Appendix B is an example of the required standard schematic.

(c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems. The record should include approximately 30-40 coloured (9 cm x 12 cm) (or 10 cm x 15 cm) prints, suitably labelled. The progress and draft reports may include photocopies in lieu of the prints.

(d) Tabulate the design parameters for all the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire (Appendix A) and must be confirmed and verified by field observations. The design parameters should be evaluated at design, rated and actual operational flows.

(e) Prepare a summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.

(f) Document all reported and other apparent problems in plant operations and/or in the distribution system related to water quality. In addition list the health related parameters which exceed the Ontario Drinking Water Objectives (Table 7).

(g) Submit 8 copies of the progress report to the Prime Consultant for distribution to the Project Committee.

4. ASSESS THE METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD UTILIZE THE PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVAL EFFICIENCY AND SENSITIVITY OF OPERATION, ASSUMING OPTIMUM PERFORMANCE OF THE PLANT.

Elements of Work

(a) Assess the validity and implication of all information relating to particulate removal provided in Work Tasks 1 and 2 with emphasis on method, metering and sampling, etc.

(b) Using information provided in Work Tasks 1, 2 and 3 evaluate the plant's particulate removal efficiency. The basis of minimum particulate removal should be 1.0 F.t.u. It should, however, be recognized that it is desirable to strive for an operational level which is as low as is achievable.

(c) Conduct an evaluation of possible optimum performance alternatives. Include jar testing using established industry practice.

(d) Evaluate the feasibility of optimum removal using the existing plant capital works. This evaluation should consider the worst case water quality conditions, even though field testing data may not be available during the initial phase of the study (see Work Task 7).

(e) Describe the operational procedures, management strategies, and equipment required for various feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation of the alternatives.

5. ASSESS CURRENT DISINFECTION PRACTICES AND POSSIBLE IMPROVEMENT METHODS.

Elements of Work

(a) Assess the validity and implication of all information relating to disinfection provided in Work Tasks 1, 2 and 3 with emphasis on method, metering and sampling etc.

(b) Using the information provided in Work Tasks 1, 2 and 3 evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives.

(c) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.

(d) Evaluate the feasibility of the various alternatives using the existing plant capital works.

(e) Assess the relative merits of the alternatives. Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL.

Elements of Work

(a) Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost and possible schedule for implementation for each of the proposed modifications.

It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.

(b) Incorporate (a) above in the draft report.

7. PREPARE A DRAFT REPORT FOR THE PROJECT COMMITTEE'S REVIEW. (8 COPIES).

Elements of Work

(a) The report must include all information for Work Tasks 1-6.

The information must be organized and presented in a logical and co-ordinated fashion. A general table of contents (Appendix C) is provided for organizing the material in a manner consistent with other plant reports.

Submit the draft report for review by the Project Committee.

(b) Meet with the Project Committee on site at least one week after submission of the report.

(c) Prepare a separate letter report containing recommendation(s) concerning the need for additional field testing to cover quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. PREPARE THE FINAL REPORT.

Elements of Work

(a) Conduct additional field testing if required. Discuss the implementations of the results with the Project Committee if the results differ from the predicted performance.

(b) Amend the report as per review comments, incorporating additional field data if required.

(c) Submit 25 copies of the final reports (including the colour photographs) to the MOE for distribution.

MINISTRY OF THE ENVIRONMENT
WATER PLANT OPTIMIZATION STUDY
KITCHENER WATER SUPPLY

WORK PLAN

INTRODUCTION

The Ontario Water Plant Optimization Study (WPOS) is being carried out in conjunction with the Drinking Water Surveillance Program (DWSP). DWSP is a continuously updated base of information on Ontario Water Plants and water quality. In connection with the DWSP, the WPOS is a plant investigation and process evaluation study for each plant entering the program.

The purpose of the WPOS is to document and review the present plant and water quality conditions, and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes.

The general Terms of Reference for the WPOS do not apply to the Kitchener water supply because they were prepared for a surface water source; the Kitchener supply uses a ground water source. Therefore, the Terms of Reference and Work Plan for the Kitchener WPOS have been re-written with a ground water supply in mind. The general Terms of Reference for the WPOS were used where applicable.

The Kitchener water supply system presently consists of seven well fields: Greenbrook, Strange Street, Mannheim East, Mannheim West, Parkway, Lancaster and Wilmot. The well fields are made up of 27 overburden wells. The water supply system also includes three induced infiltration systems along the Grand River (Forwell, Pompeii and Woolner), consisting of five horizontal collectors and four infiltration wells. The Kitchener ground water sources have a perennial yield of about 80.9 ML/day (17.8 mgd) and the well fields have a maximum capacity of 119.3 ML/day (26.3 mgd). The Kitchener system currently supplies a portion of the water needs in Waterloo and provides a water supply for fire demands in north Cambridge.

It is not the intention of the Kitchener WPOS to look at all 10 ground water sources (well fields), but to review a representative cross-section of the well fields that supply the system. Therefore, the work plan for this study will look at three well fields:

Woolner: an induced infiltration well field consisting of three horizontal collectors which has demonstrated a seasonal taste and odour problem. Disinfection is provided at this well field. The well field has a perennial yield of 10.0 ML/day (2.2 mgd) and a maximum capacity of 10.8 ML/day (2.4 mgd).

Strange Street: one of the first well fields developed in Kitchener. It consists of seven overburden wells, five connected to an upper aquifer complex and two pumping from a lower aquifer complex. Recently, very low concentrations of trichloroethylene (TCE) have been found in one Strange Street well. The average yield of the well field is 9.1 ML/day (2.0 mgd) with a maximum capacity of 15.4 ML/day (3.4 mgd).

Mannheim East/West: a high capacity overburden well field located in the area of the proposed new water supply for Kitchener, Waterloo and Cambridge - the Mannheim Artificial

Recharge Scheme. The perennial yield of Mannheim East/West is about 23.6 ML/day (5.2 mgd) with a maximum supply capability of 31.4 ML/day (6.9 mgd).

WORK PLAN

The work plan for the Kitchener WPOS has been broken down into six work tasks:

1. Prepare work plan, budget and staff requirements.

2. Document the quality and quantity of water supplies from the Woolner, Strange Street and Mannheim well fields. Define the present treatment processes used at the well fields.

3. Assess the need for disinfection/treatment of the Kitchener well fields. Assess and define the need for emergency planning for the Kitchener ground water supplies, emphasizing aquifer protection/monitoring, contaminant spill clean-up and contaminant treatment at the well head.

4. Prepare a preliminary schedule for the implementation of disinfection/treatment and emergency planning procedures for the Kitchener ground water supply.

5. Prepare seven copies of the draft report and submit to the Project Committee.

6. Review the Project Committee's comments and prepare 25 copies of the final report.

The above tasks correspond to the work tasks listed in the general Terms of Reference for the surface water plant study, where applicable.

The following outlines the elements of work associated with each task listed above.

Task 1: Prepare Work Plan, Budget and Staff Requirements

a) Consultant to meet with MOE Coordination Group to discuss approach to the study.

b) Based on Consultant's knowledge of the Kitchener ground water supply, develop a work plan for the Kitchener WPOS. The work plan will be broken down into tasks and elements of work.

c) Prepare study budget, staff requirements and update preliminary work schedule.

d) Submit work plan, budget, staff requirements and schedule to MOE.

Task 2: Document the quality and quantity of water supplies from the Kitchener well fields. Define the present treatment processes used at the well fields

a) Tabulate the daily flows at the Woolner, Strange Street and Mannheim well fields for the last three years.

b) Determine the methods of measuring the well field flow rates and assess the validity of the records.

c) Prepare a monthly summary of maximum, minimum and average flows over the three years for the well fields.

d) Summarize at least three years of water quality data for the three well fields using physical, chemical and microbiological quality information. Use as much data as is needed to show possible trends in water quality. Document the source and methods used in determining all water quality information, and assess the validity of the data.

e) Summarize the quality information from the DWSP for Kitchener, specifically the organics analyses for the three well fields.

f) Tabulate, for the last three years, the positive bacterial test information at each well head in the three well fields, and in the reservoirs and distribution system that the well fields discharge to. Document the source and methods used in determining all information. This information will be used to assess the need for disinfection of the Kitchener well supplies.

g) Identify other water quality concerns, such as the taste and odour problem in the Woolner well field, which should be considered further in Task 3.

h) Prepare a typical well layout drawing for the horizontal collectors in the Woolner well field and the overburden wells in the Strange Street and Mannheim well fields.

i) Prepare a photographic record of the works in a typical well house, illustrating chlorine feed systems where applicable.

j) Document the design criteria for chlorine feed at the wells. Define chlorine dosage control, and pumping and flow controls.

k) Document any reported problems with well field operation and/or in the distribution system related to water quality.

l) Tabulate the daily average chlorine dosages at the wells over the last three years. Document the methods used to evaluate chlorine dosages and establish the validity of the dosage information provided. Also, provide data on disinfectant residuals.

m) Submit a progress report to the Project Committee.

Task 3: Assess the need for disinfection/treatment of the Kitchener well fields. Assess and define the need for emergency planning to protect the Kitchener ground water supplies

a) Using the quality information provided in Work Task 2, assess the need for disinfection of the Kitchener ground water supplies. The basis for minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives (MOE, Revised 1983).

b) If disinfection is required, describe the operational procedures, management strategies and equipment needed. Estimate chemical dosages and level of operational expertise for disinfection.

c) Based on the information provided in Work Task 2, assess the need for remedial treatment measures to resolve the existing water quality concerns, e.g. the seasonal taste and odour problems at the Woolner well field.

d) Using the information provided in Work Task 2, assess the need for an emergency planning program for the Kitchener ground water supplies, i.e. aquifer protection/monitoring, contaminant spill clean-up and capability for contaminant treatment at the well head.

e) Define reasonable methods of protecting the quality of existing Kitchener aquifers, e.g. through development controls. Generally define the ground water quality monitoring system needed to pick up aquifer contamination.

f) Generally define the capability required for contaminant spill clean-up within the capture areas of the Kitchener well fields, e.g. methods of reporting spill events, availability of emergency crews for contaminant clean-up.

g) Outline treatment processes available for removing contaminants from a polluted aquifer in order to keep an existing well field in operation.

h) Submit a progress report to the Project Committee.

Task 4: Prepare a preliminary schedule for the implementation of disinfection/treatment and emergency planning procedures for the Kitchener ground water supplies

a) Prepare a list of needs with respect to disinfection, remedial treatment measures for existing quality concerns and emergency planning procedures. Provide an estimated cost for each of the proposed needs.

b) Prepare a preliminary schedule for implementation of the list of needs.

c) Meet with the Project Committee to review the proposed needs for the Kitchener ground water supplies.

Task 5: Prepare seven copies of the Draft Report and submit to the Project Committee

a) Prepare and submit the draft report to the Project Committee for review.

b) Prepare a separate letter containing a recommendation(s) concerning the need for field testing to cover water quality conditions not available during the period of this study, e.g. seasonal taste and odour problem at the Woolner well field. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for suggested remedial treatment measures.

Task 6: Review the Project Committee's comments and prepare 25 copies of the final report

a) Conduct additional field testing if required. Discuss the implications of the results with the Project Committee if the results differ from the predicted performance.

b) Amend the draft report as per review comments, incorporating additional field data if required.

c) Submit 25 copies of the final report to the MOE for distribution.

APPENDIX B

TABLES

TABLE 1.0: FLOWS (ML/d)

STRANGE STREET

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	R												
	T	11.89	5.43	8.03	12.56	9.79	10.86	11.50	7.84	9.39	11.15	10.42	7.29
FEB	R												
	T	12.55	10.61	10.69	11.80	6.21	10.27	12.28	6.83	7.78	11.18	8.59	7.56
MAR	R												
	T	11.95	8.16	10.14	11.10	8.33	9.14	12.42	8.88	8.96	11.12	5.13	6.46
APR	R												
	T	10.87	10.13	9.98	11.08	11.08	10.69	11.20	7.95	6.52	10.60	7.98	5.03
MAY	R												
	T	11.83	11.37	10.80	11.18	8.04	9.34	12.78	9.14	8.87	9.30	5.57	7.02
JUN	R												
	T	12.61	9.04	11.61	11.23	11.23	9.79	13.21	9.48	10.88	11.70	9.05	8.54
JUL	R												
	T	12.06	12.06	10.78	10.15	10.15	9.51	12.37	9.29	11.37	12.28	8.60	9.67
AUG	R												
	T	11.74	7.74	10.49	11.05	9.86	9.64	12.60	12.60	11.80	11.88	7.80	10.37
SEP	R												
	T	11.77	11.77	12.22	11.50	4.53	9.89	12.79	12.79	10.81	11.36	2.73	8.39
OCT	R												
	T	11.84	11.84	11.42	9.05	5.09	8.10	12.81	9.53	11.94	11.91	8.91	8.73
NOV	R												
	T	11.70	11.70	10.77	12.39	12.39	10.63	13.79	10.35	10.22	11.01	2.94	8.89
DEC	R												
	T	11.53	7.93	10.95	11.85	8.39	10.30	13.01	13.01	10.90	11.31	8.02	8.61

NOTE: Data Source is Region of Waterloo flow records

TABLE 1.0: FLOWS (ML/d)

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	R												
	T	27.19	18.40	23.89	24.30	8.39	18.75	26.53	18.30	23.53	28.82	28.82	24.55
FEB	R												
	T	27.21	27.21	22.48	28.43	19.16	21.37	27.38	12.28	22.97	28.47	23.47	26.35
MAR	R												
	T	26.83	26.83	24.02	28.25	18.89	21.01	24.11	17.85	20.92	28.55	28.55	27.09
APR	R												
	T	27.09	17.88	20.90	28.23	18.09	24.72	27.75	23.36	21.77	28.33	19.04	23.50
MAY	R												
	T	27.28	18.09	20.53	28.81	28.81	24.39	27.68	12.86	21.74	27.85	27.85	26.17
JUN	R												
	T	28.97	11.00	23.44	28.48	21.18	22.83	28.31	28.31	24.57	28.74	28.74	25.50
JUL	R												
	T	30.02	18.48	22.83	28.46	16.86	22.84	31.42	22.26	21.85	27.19	12.23	22.91
AUG	R												
	T	27.56	27.56	19.29	28.05	15.90	21.20	30.13	14.19	18.50	27.67	14.49	25.78
SEP	R												
	T	27.80	18.90	24.09	28.35	16.18	21.92	24.61	13.68	17.76	27.04	27.04	22.78
OCT	R												
	T	27.73	18.79	22.75	27.51	23.00	24.66	25.39	24.78	20.12	27.00	18.26	20.08
NOV	R												
	T	26.63	24.35	21.66	27.89	27.89	23.63	31.23	16.98	19.17	26.30	22.54	20.92
DEC	R												
	T	29.12	19.59	22.25	27.55	18.75	22.28	28.73	12.79	19.79	25.98	20.47	21.37

NOTE: Data Source is Region of Waterloo flow records

TABLE 1.0: FLOWS (ML/d)

WOOLNER

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	R T	8.41	8.41	8.32	8.50	8.50	8.49	7.23	3.00	7.54	4.29	4.29	4.30
FEB	R T	8.35	8.35	8.35	8.63	8.63	7.93	7.49	7.49	6.98	4.34	0.00	4.09
MAR	R T	8.65	0.00	4.34	8.60	0.00	7.59	7.10	7.10	6.07	7.55	0.00	2.73
APR	R T	8.65	5.94	7.94	8.56	0.00	5.22	7.10	7.10	7.33	7.55	0.00	4.71
MAY	R T	8.82	7.07	7.99	8.58	8.58	8.31	6.61	6.61	6.60	7.55	0.00	4.79
JUN	R T	8.83	8.83	7.95	9.54	0.00	2.03	5.95	0	3.12	7.34	7.34	7.26
JUL	R T	7.77	6.10	6.37	8.79	1.89	5.42	6.12	6.12	6.32	7.27	7.27	6.58
AUG	R T	9.05	1.93	8.05	8.37	0.00	6.05	7.46	0.00	7.11	7.55	0.00	5.43
SEP	R T	9.52	0.00	5.54	5.89	0.00	2.81	8.29	8.29	7.73	7.37	7.37	7.13
OCT	R T	9.16	9.16	7.89	6.13	6.13	6.13	8.27	8.27	8.60	7.27	7.27	6.99
NOV	R T	9.28	9.28	8.66	8.00	0.00	3.98	8.45	8.45	8.45	7.29	7.29	7.30
DEC	R T	8.73	8.73	9.29	8.52	6.51	8.5	8.34	8.34	6.23	7.34	7.34	7.00

NOTE: Data Source is Region of Waterloo flow records

TABLE 1.1: DAILY FLOWS (ML/d) 1986

STRANGE ST. FIELD
MOE WPOS PROTOCOL

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE				10.13								
WED												
THU												
FRI	8.37	12.55	8.16	10.42	11.37	12.61	12.06	7.74	11.77	11.84	11.70	8.80
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	5.43	10.61	11.95	10.42	11.37	12.61	12.06	11.74	11.77	11.84	11.70	11.53
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	10.91	10.61	11.95	10.42	11.37	12.61	12.06	11.74	11.77	11.84	11.70	11.53
SAT												
SUN												

TABLE 1.1 (cont'd.)

STRANGE 86

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												7.93
THU			11.95									
FRI	11.89	11.58		10.42	11.37		12.06	11.74	11.77	11.84	11 .70	
SAT												
SUN												
MON						9 04						
TUE									11.77			
WED				10.87								7.93
THU							12.06					
FRI	11.89				11.83					11.84		
SAT												
SUN												
MON												
TUE												
MAX	11.89	12.55	11.95	10.87	11.83	12.61	12.06	11.74	11.77	11.84	11.70	11.53
MIN	5.43	10.61	8.16	10.13	11.37	9.04	12.06	7.74	11.77	11.84	11.70	7.93
AVG	8.03	10.69	10.14	9.98	10.80	11.61	10.78	10.49	12.22	11.42	10.77	10.95

TABLE 1.1: DAILY FLOWS (ML/d) 1985

STRANGE ST. FIELD
MOE WPOS PROTOCOL

Page 1 of 2

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON										5.09		
TUE												
WED												
THU				11.08								
FRI	9.79	11.80	11.10		10.39	11.23	10.15	9.86	11.50	9.05	12.39	11.85
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	10.05	6.21	8.33	11.08	11.18	11.23	10.15	11.50	11.50	6.38	12.39	8.39
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	12.56	11.80	11.10	11.08	8.04	11.23	10.15	11.50	6.19	9.05	12.39	11.85
SAT												
SUN												

TABLE 1.1 (cont'd.)

STRANGE 85

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU		11.80								8.03		
FRI	12.56		11.10		11.18	11.23	10.15	11.05			12.39	
SAT												
SUN												
MON									4.53			
TUE				11.08								8.39
WED							10.15	11.05				
THU	12.56											
FRI					11.18							
SAT												
SUN												
MON												
TUE												
MAX	12.56	11.80	11.10	11.08	11.18	11.23	10.15	11.05	11.50	9.05	12.39	11.85
MIN	9.79	6.21	8.33	11.08	8.04	11.23	10.15	9.86	4.53	5.09	12.39	8.39
AVG	10.86	10.27	9.14	10.69	9.34	9.79	9.51	9.64	9.89	8.10	10.63	10.30

TABLE 1.1: DAILY FLOWS (ML/d) 1984

STRANGE ST. FIELD
MOE WPOS PROTOCOL

DAY	JAN.	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	11.50	6.83	11.70	11.20	11.40	12.37	12.37	12.60	12.79	12.30	12.99	13.01
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	7.84	6.83	12.39	7.95	9.14	9.48	9.29	12.60	12.79	9.53	10.25	13.01
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	10.77	9.79	12.39	7.88	12.78	13.21	12.37	12.60	12.79	12.81	13.75	13.01
SAT												
SUN												

TABLE 1.1 (cont'd.)

STRANGE 84

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	11.50	12.28	8.88		10.91	12.56	12.37	12.60	12.79	9.55	10.35	
SAT												
SUN												
MON				7.95								13.01
TUE	9.83						12.37					
WED		11.55								12.81		
THU												
FRI			12.42			12.56					13.75	
SAT												
SUN												
MON												
TUE												
MAX	11.50	12.28	12.42	11.20	12.78	13.21	12.37	12.60	12.79	12.81	13.75	13.01
MIN	7.84	6.83	8.88	7.95	9.14	9.48	9.29	12.60	12.79	9.53	10.35	13.01
AVG	9.39	7.78	8.96	6.52	8.87	10.88	11.37	11.80	10.81	11.94	10.22	10.90

TABLE 1.1: DAILY FLOWS (ML/d) 198_3

STRANGE ST. FIELD
MOE WPOS PROTOCOL

Page 1 of 2

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	10.42	11.18	11.08	10.60	8.65	9.05	9.29	7.80	11.36	9.78	11.01	11.31
SAT												
SUN												
MON												
TUE												
WED												
THU											11.01	
FRI	11.15	8.59	10.36	10.60	9.30	11.70	12.28	11.88	9.07	11.91		8.02
SAT												
SUN												
MON												
TUE												
WED												
THU											11.01	
FRI	11.15	8.59	11.12	7.98	9.30	9.05	12.28	11.88	8.33	11.91		10.91
SAT												
SUN												

TABLE 1.1 (cont'd.)

STRANGE 83

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												8.02
FRI	10.42	11.18	7.11	7.99	5.57	9.05	8.60	11.14	2.73	8.91	11.01	
SAT												
SUN												
MON	11.15	11.18								11.91		
TUE					7.31							
WED								11.14			2.94	
THU			5.13			9.05						
FRI									7.16			10.91
SAT												
SUN												
MON												
TUE												
MAX	11.15	11.18	11.12	10.60	9.30	11.70	12.28	11.88	11.36	11.91	11.01	11.31
MIN	10.42	8.59	5.13	7.98	5.57	9.05	8.60	7.80	2.73	8.91	2.94	8.02
AVG	7.29	7.56	6.46	5.03	7.02	8.54	9.67	10.37	8.39	8.73	8.89	8.66

TABLE 1.1: DAILY FLOWS (ML/d) 1986

MANNHEIM FIELD
MOE WPOS PROTOCOL

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE				26.83								
WED												
THU												
FRI	18.40	27.21	26.83	27.09	18.09	28.97	18.48	27.56	18.90	27.73	26.63	25.35
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	27.19	27.21	26.83	17.88	22.36	17.24	30.02	27.56	27.80	27.73	26.63	25.35
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	27.19	27.21	26.83	22.04	18.09	28.97	30.02	27.56	27.80	22.30	24.35	29.12
SAT												
SUN												

TABLE 1.1 (cont'd.)

MANNHEIM 86

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												29.12
THU			26.83									
FRI	27.19	27.21		22.04	27.28		26.44	27.56	27.80	18.79	24.35	
SAT												
SUN												
MON						11.00						
TUE									27.80			
WED				17.88								19.59
THU							26.44					
FRI	27.19			27.28						27.73		
SAT												
SUN												
MON												
TUE												
MAX	27.19	27.21	26.83	27.09	27.28	28.97	30.02	27.56	27.80	27.73	26.63	29.12
MIN	18.40	27.21	26.83	17.88	18.09	11.00	18.48	27.56	18.90	18.79	24.35	19.59
AVG	23.89	22.48	24.02	20.90	20.53	23.44	22.83	19.29	24.09	22.75	21.66	22.25

TABLE 1.1: DAILY FLOWS (ML/d) 198_5

MANNHEIM FIELD
MOE WPOS PROTOCOL

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	8.39	28.43	28.25	28.23	28.81	28.48	28.46	15.90	20.16	23.0	27.89	27.55
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	24.30	28.43	18.89	28.23	28.81	21.18	16.86	28.05	28.35	27.51	27.89	18.74
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	19.76	19.16	28.25	18.09	28.81	28.48	21.01	28.05	28.35	27.51	27.89	18.74
SAT												
SUN												

TABLE 1.1 (cont'd.)

Page 2 of 2

MANNHEIM 85

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU		23.69										
FRI	24.30		28.25		28.81	28.48	24.21	28.05	16.18	27.51	27.89	
SAT												
SUN												
MON												
TUE				28.23								18.74
WED							16.86					
THU	24.30									27.51		
FRI					28.81			28.05				
SAT												
SUN												
MON												
TUE												
MAX	24.30	28.43	28.25	28.23	28.81	28.48	28.46	28.05	28.35	27.51	27.89	27.55
MIN	8.39	19.16	18.89	18.09	28.81	21.18	16.86	15.90	16.18	23.0	27.89	18.75
AVG	18.57	21.37	21.01	24.72	24.39	22.83	22.84	21.20	21.92	24.66	23.63	22.28

TABLE 1.1: DAILY FLOWS (ML/d) 198^{4}

MANNHEIM FIELD
MOE WPOS PROTOCOL

DAY	JAN.	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	26.53	18.41	17.85	27.95	12.86	28.31	31.42	19.23	13.68	24.78	26.68	28.73
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	26.53	27.38	24.11	23.36	27.68	28.31	22.26	25.08	24.61	24.78	21.35	28.73
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	18.30	27.38	24.11	23.36	27.68	28.31	22.26	23.82	24.61	25.39	16.98	28.73
SAT												
SUN												

TABLE 1.1 (cont'd.)

MANNHEIM 84

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	26.53	12.28	24.11		27.68	28.31	22.26	14.19	24.61	25.39	31.23	
SAT												
SUN												
MON				27.95			31.42					12.79
TUE	18.30											
WED		12.28								25.39		
THU												
FRI			23.59		23.68			30.13			26.86	
SAT												
SUN												
MON												
TUE												
MAX	26.53	27.38	24.11	27.95	27.68	28.31	31.42	30.13	24.61	25.39	31.23	28.73
MIN	18.30	12.28	17.85	23.36	12.86	28.31	22.26	14.19	13.68	24.78	16.98	12.79
AVG	23.53	22.97	20.92	21.77	21.74	24.51	21.85	18.50	17.76	20.12	19.17	19.79

TABLE 1.1: DAILY FLOWS (ML/d) 1983

MANNHEIM FIELD
MOE WPOS PROTOCOL

Page 1 of 2

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	28.82	28.47	28.55	28.33	27.85	28.74	27.19	27.67	27.04	27.06	26.30	20.47
SAT												
SUN												
MON												
TUE												
WED												
THU											26.30	
FRI	28.82	28.47	28.55	19.04	27.85	28.74	27.19	27.67	27.04	27.06		20.75
SAT												
SUN												
MON												
TUE												
WED												
THU											22.54	
FRI	28.82	28.47	28.55	28.33	27.85	28.74	27.19	14.49	27.04	27.06		20.75
SAT												
SUN												

TABLE 1.1 (cont'd.)

MANNHEIM 83

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												20.75
FRI	28.82	28.47	28.55	28.33	27.85	28.74	12.23	22.68	27.04	18.76	26.30	
SAT												
SUN												
MON	28.82	28.47								27.06		
TUE					27.85							
WED								27.67			26.30	
THU			28.55									25.98
FRI						28.74			27.04			
SAT												
SUN												
MON												
TUE												
MAX	28.82	28.47	28.55	28.33	27.85	28.74	27.19	27.67	27.04	27.06	26.30	25.98
MIN	28.82	28.47	28.55	19.04	27.85	28.74	12.23	14.49	27.04	18.26	22.54	20.47
AVG	24.55	26.35	27.09	23.50	26.17	25.50	22.91	25.78	22.78	20.08	20.92	21.37

TABLE 1.1: DAILY FLOWS (ML/d) 1986

WCOLNER FIELD
MOE WPOS PROTOCOL

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE				8.65								
WED												
THU												
FRI	8.41	8.35	8.65	8.44	7.07	8.83	7.77	9.05	9.52	9.16	9.28	8.73
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	8.41	8.35	0	5.94	8.82	8.83	6.10	9.05	0	9.16	9.28	8.73
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	8.41	8.35	0	8.44	8.82	8.83	7.77	9.05	9.52	9.16	9.28	8.73
SAT												
SUN												

TABLE 1.1 (cont'd.)

WOOLNER 86

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON						8.83						
TUE												
WED												8.73
THU			8.65									
FRI	8.41	8.45		8.44	8.82		7.77	1.93	0	9.16	9.28	
SAT												
SUN												
MON						8.83						
TUE									2.03			
WED				8.44								8.73
THU						7.77						
FRI	8.41				8.82					9.16		
SAT												
SUN												
MON												
TUE												
MAX	8.41	8.35	8.65	8.65	8.82	8.83	7.77	9.05	9.52	9.16	9.28	8.73
MIN	8.41	8.35	0	5.94	7.07	8.83	6.10	1.93	0	9 16	9.28	8.73
AVG	8.32	8.35	4.34	7.94	7.99	7.95	6.37	8.05	5.54	7.89	8.66	9.29

TABLE 1.1: DAILY FLOWS (ML/d) 1985

WCCLNER FIELD
MOE WPOS PROTOCOL

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE						0						
WED												
THU												
FRI	8.50	8.63	8.60		0	0	8.79	8.37	0	6.13	5.97	6.51
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	8.50	8.63	8.60	5.88	8.58	9.54	1.89	8.37	0	6.13	0	8.52
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	8.50	8.63	8.60	8.56	8.58	9.54	6.27	8.37	5.89	6.13	5.97	8.52
SAT												
SUN												

TABLE 1.1 (cont'd.)

Page 2 of 2

WOOLNER 85

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU		8.63										
FRI	8.50		0		8.58	9.54	8.79	8.37		6.13	8.00	8.52
SAT												
SUN												
MON									5.89			
TUE				0								8.52
WED												
THU	8.50									6.13		
FRI					8.58		8.79	0				
SAT												
SUN												
MON												
TUE												
MAX	8.50	8.63	8.60	8.56	8.58	9.54	8.79	8.37	5.89	6.13	8.00	8.52
MIN	8.50	8.63	0	0	8.58	0	1.89	0	0	6.13	0	6.51
AVG	8.49	7.93	7.59	5.22	8.31	2.03	5.42	6.05	2.8	6.13	3.98	8.59

TABLE 1.1: DAILY FLOWS (ML/d) 1984

WOOLNER FIELD
MOE WPOS PROTOCOL

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	7.23	7.49	7.10	7.10	6.61	5.95	6.12	5.41	8.29	8.27	8.45	8.34
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	7.23	7.49	7.10	7.10	6.61	0	6.12	7.46	8.29	8.27	8.455	5.94
SAT												
SUN												
MON												
TUE												
WED												
THU												
FRI	7.23	7.49	7.10	7.10	6.61	0	6.12	7.46	8.29	8.27	8.45	8.34
SAT												
SUN												

TABLE 1.1 (cont'd.)

WOOLNER 84

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												
FRI	3.00	7.49	0		6.61	5.95	6.12	7.46	8.29	8.27	8.45	
SAT												
SUN												
MON	7.26			7.10								8.34
TUE								6.12				
WED		7.49								8.27		
THU												
FRI			7.10		6.61			0			8.45	
SAT												
SUN												
MON												
TUE												
MAX	7.23	7.49	7.10	7.10	6.61	5.95	6.12	7.46	8.29	8.27	8.45	8.34
MIN	3.00	7.49	0	7.10	6.61	0	6.12	0	8.29	8.27	8.45	8.34
AVG	7.54	6.98	6.07	7.33	6.60	3.12	6.32	7.11	7.73	8.60	8.45	6.23

TABLE 1.1: DAILY FLOWS (ML/d) 198_3

WOOLNER FIELD

MOE WPOS PROTOCOL

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE				3.76								
WED												
THU												
FRI	4.29	0	4.27	3.26	0	7.34	7.27	7.55	7.37	7.27	7.29	7.34
SAT												
SUN												
MON												
TUE												
WED												
THU											7.29	
FRI	4.29	4.34	0	0	7.01	7.34	7.27	0	7.37	7.27		7.34
SAT												
SUN												
MON												
TUE												
WED												
THU											7.29	
FRI	4.29	4.34	4.27	7.55	0	7.34	7.27	7.55	7.37	7.27		7.34
SAT												
SUN												

TABLE 1.1 (cont'd.)

WOOLNER 83

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON												
TUE												
WED												
THU												7.34
FRI	4.29	4.34	0	7.55	7.01	7.34	7.27	7.55	7.37	7.27	7.29	
SAT												
SUN												
MON	4.29	4.34								7.27		
TUE					7.01							
WED											7.29	
THU			0									
FRI						7.34		7.55	7.37			7.34
SAT												
SUN												
MON												
TUE												
MAX	4.29	4.34	4.27	7.55	7.55	7.34	7.27	7.55	7.37	7.27	7.29	7.34
MIN	4.29	0	0	0	0	7.34	7.27	0	7.37	7.27	7.29	7.34
AVG	4.30	4.09	2.73	4.71	4.29	7.26	6.58	5.43	7.13	6.99	7.30	7.00

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

Page 1 of 1

MONTH	PARAMETER			MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	Turbidity (FTU)		R												
			T												
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)													
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R												
			T												
	Temperature	(°C)													
FEB	Turbidity (FTU)		R												
			T												
	Colour (TCU)		R												
			T												
	Prime Coagulant	(mg/L)													
	Coagulant Aid	(mg/L)													
	(1)	(mg/L)													
	(2)	(mg/L)													
	(3)	(mg/L)													
	(4)	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R												
			T												
	Temperature	(°C)													

NOTE: This table was not applicable to the Kitchener WPOS because the watersupply source is ground water

TABLE 3.0: DISINFECTION SUMMARY - Strange Street K10

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage			0.56									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.15	0.27									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
FEB	Cl_2 Demand												
	Cl_2 Dosage			0.93									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.8	0.01	0.58									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAR	Cl_2 Demand												
	Cl_2 Dosage			0.79									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.6	0.6	0.6									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			1.20									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.15	0.15	0.15									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAY	Cl_2 Demand												
	Cl_2 Dosage			0.93									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
JUN	Cl_2 Demand												
	Cl_2 Dosage			1.20									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			1.31									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	1.0	0.15	0.44									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
AUG	Cl_2 Demand												
	Cl_2 Dosage			1.38			1.09						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.6	0.1	0.35	0.4	0.4	0.4						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
SEP	Cl_2 Demand												
	Cl_2 Dosage			1.38			1.69						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.5	0.5	0.5	0.5	0.5						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			1.28			1.99						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.8	0.2	0.5	0.5	0.15	0.28						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
NOV	Cl_2 Demand												
	Cl_2 Dosage			0.92			1.63						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.15	0.35	1.5	1.5	1.5						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
DEC	Cl_2 Demand												
	Cl_2 Dosage			--			1.53						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.15	0.05	0.1	0.15	0.15	0.15						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

NOTE: Data Source is Region of Waterloo well records
Test frequency is weekly (sometimes less often)

TABLE 3.0: DISINFECTION SUMMARY - Strange Street K11

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST -CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage Sodium Chlorite			0.52									
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.43									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
FEB	Cl_2 Demand												
	Cl_2 Dosage Sodium Chlorite			0.42									
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.2	0.2	0.2									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAR	Cl_2 Demand												
	Cl_2 Dosage Sodium Chlorite			0.21									
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Strange Street Kil

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			0.55									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAY	Cl_2 Demand												
	Cl_2 Dosage			0.47									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
JUN	Cl_2 Demand												
	Cl_2 Dosage			0.49									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Strange Street Kill

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			0.47									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.3	0.3	0.3									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
AUG	Cl_2 Demand												
	Cl_2 Dosage			0.51			0.93						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.25	0.2	0.22	0.5	0.4	0.45						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
SEP	Cl_2 Demand												
	Cl_2 Dosage			0.49			1.16						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--	0.6	0.6	0.6						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Strange Street K11

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			0.39			0.63						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--	--	--	--						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
NOV	Cl_2 Demand												
	Cl_2 Dosage			0.29			0.66						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.1	0.1	0.1	0.5	0.45	0.48						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
DEC	Cl_2 Demand												
	Cl_2 Dosage			--			0.63						
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--	0.5	0.5	0.5						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

NOTE: Data Source is Region of Waterloo well records
Test frequency is weekly (sometimes less often)

TABLE 3.0: DISINFECTION SUMMARY - Strange Street K13

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST -CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage			0.42									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
FEB	Cl_2 Demand												
	Cl_2 Dosage			0.65									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAR	Cl_2 Demand												
	Cl_2 Dosage			0.46									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.1	0.1	0.1									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Strange Street K13

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			0.52									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	1.5	1.5	1.5									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAY	Cl_2 Demand												
	Cl_2 Dosage			0.47									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
JUN	Cl_2 Demand												
	Cl_2 Dosage			0.55									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Strange Street K13

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			0.69									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.2	0.1	0.17									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
AUG	Cl_2 Demand												
	Cl_2 Dosage			0.57									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.2	0.2	0.2									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
SEP	Cl_2 Demand												
	Cl_2 Dosage			0.49									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Strange Street K13

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			0.43									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
NOV	Cl_2 Demand												
	Cl_2 Dosage			0.37									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
DEC	Cl_2 Demand												
	Cl_2 Dosage			--									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	--	--	--									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

NOTE: Data Source is Region of Waterloo well records
Test frequency is weekly (sometimes less often)

TABLE 3.0: DISINFECTION SUMMARY - MANNHEIM K21

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage												
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free												
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
FEB	Cl_2 Demand												
	Cl_2 Dosage												
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free												
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAR	Cl_2 Demand												
	Cl_2 Dosage												
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free												
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) _ MANNHEIM K21

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage												
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free												
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAY	Cl_2 Demand												
	Cl_2 Dosage												
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free												
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
JUN	Cl_2 Demand												
	Cl_2 Dosage												
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free												
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - MANNHEIM K21

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage												
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free												
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
AUG	Cl_2 Demand												
	Cl_2 Dosage			0.54									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	-	-	-									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
SEP	Cl_2 Demand												
	Cl_2 Dosage			1.28									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	-	-	-									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - MANNHEIM K21

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			1.56									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	-	-	-									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
NOV	Cl_2 Demand												
	Cl_2 Dosage			1.98									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	-	-	-									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
DEC	Cl_2 Demand												
	Cl_2 Dosage			-									
	Sodium Chlorite												
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	-	-	-									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

NOTE: Data source is Region of Waterloo well records
Test frequency is weekly (sometimes less often)

TABLE 3.0: DISINFECTION SUMMARY - Woolner K80

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage			1.00			0.87						
	Sodium Chlorite			0.38			--						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.6	0.5	0.53	0.8	0.55	0.65						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
FEB	Cl_2 Demand												
	Cl_2 Dosage			0.94			0.46						
	Sodium Chlorite			0.38			--						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.7	0.5	0.58	0.6	0.4	0.5						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAR	Cl_2 Demand												
	Cl_2 Dosage			0.91			0.79						
	Sodium Chlorite			0.37			--						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.55	0.55	0.55	0.75	0.6	0.65						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Woolner K80

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			0.85			1.20						
	Sodium Chlorite			0.34			0.35						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.5	0.5	0.7	0.7	0.7						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAY	Cl_2 Demand												
	Cl_2 Dosage			0.80			1.18						
	Sodium Chlorite			0.29			0.53						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.45	0.7	0.7	0.7						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
JUN	Cl_2 Demand												
	Cl_2 Dosage			0.81			5.50						
	Sodium Chlorite			0.37			2.38						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.4	0.4	--	--	--						
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Woolner K80

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			0.78			--						
	Sodium Chlorite			1.02			--						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.35	0.38									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
AUG	Cl_2 Demand												
	Cl_2 Dosage			0.86			1.07			0.57			
	Sodium Chlorite			0.35			0.51			0.46			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.35	0.37	0.5	0.45	0.48	0.4	0.25	0.33			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
SEP	Cl_2 Demand												
	Cl_2 Dosage			0.82			--			0.73			
	Sodium Chlorite			0.39			--			0.29			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.3	0.35	--	--	--	0.4	0.45	0.48			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Woolner K80

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			0.77			--			0.89			
	Sodium Chlorite			0.30			--			0.32			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.45	0.4	0.41	--	--	--	0.5	0.45	0.49			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
NOV	Cl_2 Demand												
	Cl_2 Dosage			0.79			1.22			0.94			
	Sodium Chlorite			0.31			0.24			--			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.44	--	--	--	0.7	0.5	0.6			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
DEC	Cl_2 Demand												
	Cl_2 Dosage			--			0.99			0.93			
	Sodium Chlorite			0.25			0.46			--			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.6	0.5	0.53	0.6	0.4	0.5	0.6	0.6	0.6			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

NOTE: Data source is Region of Waterloo well records
Test frequency is weekly (sometimes less often)

TABLE 3.0: DISINFECTION SUMMARY - Woolner K81

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST -CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage			0.84			0.91			0.47			
	Sodium Chlorite			0.31			--			--			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.44	0.7	0.6	0.65	0.4	0.3	0.38			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
FEB	Cl_2 Demand												
	Cl_2 Dosage			0.83			0.87			0.46			
	Sodium Chlorite			0.36			--			--			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.75	0.3	0.46	0.75	0.5	0.64	0.4	0.3	0.37			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAR	Cl_2 Demand												
	Cl_2 Dosage			0.94			0.61			0.54			
	Sodium Chlorite			0.35			--			--			
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.5	0.5	0.7	0.6	0.63	0.5	0.35	0.42			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			0.95			0.79			0.54			0.43
	Sodium Chlorite			0.39			0.25			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.7	0.5	0.56	0.6	0.6	0.6	0.5	0.35	0.44	0.35	0.3	0.33
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAY	Cl_2 Demand												
	Cl_2 Dosage			0.84			0.91			0.58			0.43
	Sodium Chlorite			0.32			0.39			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.45	0.49	0.6	0.5	0.55	0.5	0.3	0.42	0.3	0.3	0.3
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
JUN	Cl_2 Demand												
	Cl_2 Dosage			0.84			2.26			1.08			0.53
	Sodium Chlorite			0.37			0.92			0.47			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.45	0.47	--	--	--	0.7	0.4	0.55	0.45	0.3	0.33
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Woolner K81

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			0.75			0.81			0.76			0.45
	Sodium Chlorite			0.34			0.37			0.26			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.35	0.43	0.4	0.4	0.4	0.55	0.3	0.4	0.4	0.3	0.33
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
AUG	Cl_2 Demand												
	Cl_2 Dosage			0.71			1.13			0.70			0.40
	Sodium Chlorite			0.26			0.33			0.35			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.35	0.4	0.4	0.35	0.39	0.5	0.3	0.39	0.35	0.2	0.3
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
SEP	Cl_2 Demand												
	Cl_2 Dosage			0.76			0.89			0.76			0.45
	Sodium Chlorite			0.30			0.34			0.27			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.35	0.38	0.4	0.4	0.4	0.5	0.4	0.45	0.3	0.25	0.28
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			1.93			0.92			0.87			0.45
	Sodium Chlorite			0.79			0.41			0.36			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.45	0.45	0.4	0.41	0.5	0.5	0.5	0.35	0.3	0.34
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
NOV	Cl_2 Demand												
	Cl_2 Dosage			0.79			0.88			0.88			0.48
	Sodium Chlorite			0.31			0.33			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.5	0.5	0.55	0.5	0.52	0.6	0.5	0.54	0.3	0.25	0.29
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
DEC	Cl_2 Demand												
	Cl_2 Dosage			--			0.81			0.83			0.47
	Sodium Chlorite			0.20			0.35			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.6	0.5	0.52	0.5	0.5	0.5	0.6	0.6	0.6	0.45	0.3	0.37
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

NOTE: Data source is Region of Waterloo well records
Test frequency is weekly (sometimes less often)

TABLE 3.0: DISINFECTION SUMMARY - Woolner K82

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST -CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage			0.64			0.50			0.20			0.43
	Sodium Chlorite			0.22			--			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.47	0.6	0.4	0.48	0.3	0.2	0.22	0.4	0.35	0.38
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
FEB	Cl_2 Demand												
	Cl_2 Dosage			0.61			0.41			0.26			0.39
	Sodium Chlorite			0.24			--			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	.3	0.43	0.4	0.3	0.37	0.3	0.2	0.25	0.35	0.3	0.32
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAR	Cl_2 Demand												
	Cl_2 Dosage			0.56			0.34			0.32			0.30
	Sodium Chlorite			0.24			--			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	.5	.5	0.5	.4	.4	0.4	0.3	0.3	0.3	0.3	0.25	0.28
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			0.57			0.28			0.26			0.28
	Sodium Chlorite			0.22			0.10			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.45	0.3	0.3	0.3	0.4	0.3	0.33	0.4	0.4	0.4
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
MAY	Cl_2 Demand												
	Cl_2 Dosage			0.54			0.30			0.34			0.29
	Sodium Chlorite			0.29			0.13			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.43	0.3	0.3	0.3	0.45	0.3	0.36	0.4	0.3	0.35
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
JUN	Cl_2 Demand												
	Cl_2 Dosage			0.51			1.15			0.52			0.29
	Sodium Chlorite			0.18			0.42			0.21			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.35	0.38	--	--	--	0.4	0.4	0.4	0.3	0.2	0.23
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Woolner K82

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			0.53			0.68			0.36			0.33
	Sodium Chlorite			0.24			0.30			0.12			0.19
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.45	0.3	0.35	0.5	0.35	0.42	0.3	0.2	0.23	0.3	0.2	0.26
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
AUG	Cl_2 Demand												
	Cl_2 Dosage			0.52			0.67			0.37			0.29
	Sodium Chlorite			0.22			0.27			0.19			0.18
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.35	0.38	0.4	0.4	0.4	0.3	0.2	0.25	0.25	0.2	0.22
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
SEP	Cl_2 Demand												
	Cl_2 Dosage			0.57			0.68			0.47			0.31
	Sodium Chlorite			0.18			0.12			0.17			0.11
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.4	0.35	0.38	0.4	0.4	0.4	0.35	0.2	0.28	0.2	0.2	0.2
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

TABLE 3.0 (cont'd.) - Woolner K82

		1986			1985			1984			1983		
		POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			0.59			0.63			0.58			0.31
	Sodium Chlorite			0.25			0.28			0.24			0.18
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.44	0.4	0.4	0.4	0.5	0.5	0.5	0.3	0.2	0.25
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
NOV	Cl_2 Demand												
	Cl_2 Dosage			0.60			0.66			0.61			0.34
	Sodium Chlorite			0.24			0.25			0.07			0.13
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.5	0.4	0.48	0.5	0.35	0.43	0.55	0.5	0.49	0.3	0.25	0.26
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												
DEC	Cl_2 Demand												
	Cl_2 Dosage			--			0.65			0.43			0.24
	Sodium Chlorite			0.16			0.28			--			--
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.7	0.3	0.5	0.5	0.4	0.45	0.6	0.4	0.48	0.25	0.2	0.21
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total												

NOTE: Data source is Region of Waterloo well records
Test frequency is weekly (sometimes less often)

TABLE 4.0

WPOS

PLANT STRANGE STATION WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY	R	299.3	277.2	288.3	320.4	293.6	307	293.8	290.6	292.2	312.9	271.5	292.2	0.2	
mg/L	T													mg/L	
AMMONIUM TOTAL	R							.10	.05	0.08	<.05<	<.05<	<.05<	0.05	
mg/L	T													mg/L	
CALCIUM	R							120.0	116.0	118.0	124.0	100.0	112.0	0.1	
mg/L	T													mg/L	
CHLORIDE	R	87.2	37.8	62.5	75.8	62.8	69.3	92.4	73.4	82.9	85.8	70.0	77.9	0.2	250
mg/L	T													mg/L	mg/L
COLOUR TCU	R													0.5	5
	T													TCU	TCU
CONDUCTIVITY	R	1000.	880.0	940.0	906.0	904.0	905.0	963	910	936.5	985	873	929	0.01	
umho/cm	T													UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

TABLE 4.0 PLANT STRANGE STATION WPOS WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE °C	R T														
FIELD TURBIDITY FTU	R T														1 FTU
FLUORIDE mg/L	R T	.12	.08	.10	.12	.10	.11	.15	.11	.13	.09	.06	.08	0.01 mg/L	2.4 mg/L
HARDNESS mg/L	R T	466.6	422.7	444.7	457.5	420.5	439	446.0	431.7	438.9	456.0	393.0	424.5	0.5 mg/L	
MAGNESIUM mg/L	R T							35.5	34.5	35.0	35.5	34.8	35.2	0.05 mg/L	c
NITRATE mg/L	R T							.35	.30	.33	.35	.30	.33	0.05 mg/L	10 mg/L as N
NITRITE mg/L	R T													0.005 mg/L	1 mg/L as N
NITROGEN TOTAL KJELDAHL mg/L	R T							.20<	.10<		<.20<	<.10<		0.1 mg/L	0.15 mg/L *
PH	R T	7.45	7.41	7.43	7.48	7.47	7.48	7.37	7.34	7.36	8.05	7.92	7.99		
PHOSPHORUS FILTERED REACTIVE mg/L	R T													0.01 mg/L	

WPOS

TABLE 4.0 PLANT STRANGE STATION WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R							.020<	.010<		.020<	.010<		0.01	
mg/L	T													mg/L	
SODIUM	R	35.7	15.7	25.7	37.4	27.0	32.2	43.4	32.0	37.7	36.9	30.8	33.9	0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R													0.01	1
FTU	T													FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

WPOS

TABLE 4.0 PLANT STRANGE STATION WATER QUALITY – 4-YEAR SUMMARY ( )

METALS (Cont'd)			1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM	mg/L	R													0.001 mg/L	0.05 mg/L
		T														
COBALT	mg/L	R													0.001 mg/L	
		T														
COPPER	mg/L	R													0.001 mg/L	1 mg/L
		T														
CYANIDE	mg/L	R													0.001 mg/L	0.2 mg/L
		T														
IRON	mg/L	R	.08	.05	.07	.04<	.03<	.03<	.093	.03<	.062	.210	.140	.175	0.002 mg/L	0.3 mg/L c
		T														
LEAD	mg/L	R													0.003 mg/L	0.05 mg/L
		T														
MANGANESE	mg/L	R							.055	.037	.046	.084	.050	.067	0.001 mg/L	0.05 mg/L
		T														
MOLYBDENUM	mg/L	R													0.001 mg/L	
		T														
MERCURY	ug/L	R													0.01 ug/L	1 ug/L
		T														
NICKEL	mg/L	R													0.002 mg/L	
		T														

NOTE: Data source is the Region of Waterloo water quality records
Sample frequency twice annually

TABLE 4.0 PLANT K-14

WPOS
WATER QUALITY - 4-YEAR SUMMARY ( )

Page 1

GENERAL CHEMISTRY		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE^1
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY	R	251.4	244.4	247.9	255.6	251.0	253.3	251.0	250.2	250.7	264.8	246.4	255.6	0.2	
mg/L	T													mg/L	
AMMONIUM TOTAL	R							.10<	<.05<		<.05<	<.05<		0.05	
mg/L	T													mg/L	
CALCIUM	R							94.0	91.0	92.5	99.8	88.0	93.5	0.1	
mg/L	T													mg/L	
CHLORIDE	R	18.6	16.8	17.7	18.0	17.0	17.5	19.6	18.8	19.2	28.70	22.70	25.7	0.2	250
mg/L	T													mg/L	mg/L
COLOUR TCU	R													0.5	5
	T													TCU	TCU
CONDUCTIVITY	R	795	687	741	684	632	658	680	670	675	760	684	704	0.01	
umho/cm	T													UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

TABLE 4.0

PLANT K-14

WPOS

WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE	R														
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R	.16	.16	.16	.18	.18	.18	.19	.17	.18	.15	.05	.10	0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	366.9	360.7	363.8	357.3	345.3	351.3	370.0	359.0	364.5	386.0	352.5	369.25	0.5	
mg/L	T													mg/L	
MAGNESIUM	R							32.80	32.00	32.4	33.20	32.20	32.7	0.05	
mg/L	T													mg/L	c
NITRATE	R							.05<	<.05<	<.05	.10<	<.05<		0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R													0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R							.10<	.10<		.20<	<.20<		0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	7.73	7.57	7.65	7.59	7.49	7.54	7.57	7.49	7.53	8.25	7.78	8.01		
	T														
PHOSPHORUS FILTERED REACTIVE	R													0.01	
mg/L	T													mg/L	

TABLE 4.0 PLANT K-14 WPOS WATER QUALITY – 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R							.010<	<.010<	<0.01	.020<	<.020<	<.02	0.01	
mg/L	T													mg/L	
SODIUM	R	11.4	10.0	10.7	11.2	10.7	11.0	11.5	10.5	11.0	15.0	11.8	13.5	0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R													0.01	1
FTU	T													FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 4.0

PLANT K-14

WPOS
WATER QUALITY - 4-YEAR SUMMARY ( )

METALS (Cont'd)			1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM	mg/L	R T													0.001 mg/L	0.05 mg/L
COBALT	mg/L	R T													0.001 mg/L	
COPPER	mg/L	R T													0.001 mg/L	1 mg/L
CYANIDE	mg/L	R T													0.001 mg/L	0.2 mg/L
IRON	mg/L	R T	.34	.33	.34	.32	.23	.28	.360	.31	.335	.320	.055	0.188	0.002 mg/L	0.3 mg/L c
LEAD	mg/L	R T													0.003 mg/L	0.05 mg/L
MANGANESE	mg/L	R T							.220	.210	.215	.220	.200	.210	0.001 mg/L	0.05 mg/L
MOLYBDENUM	mg/L	R T													0.001 mg/L	
MERCURY	ug/L	R T													0.01 ug/L	1 ug/L
NICKEL	mg/L	R T													0.002 mg/L	

NOTE: Data source is the Region of Waterloo water quality records
Sample frequency twice annually

WPOS

TABLE 4.0 PLANT K-18 WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY	R	267.6	223.4	245.5	282.6	279.4	281	285	279.6	282.3	294.5	254.5	274.5	0.2	
mg/L	T													mg/L	
AMMONIUM TOTAL	R							.05<	<.05<	.05<	<.05<	<.05<	.05<	0.05	
mg/L	T													mg/L	
CALCIUM	R							108.0	103.0	105.5	109.0	86.5	97.8	0.1	
mg/L	T													mg/L	
CHLORIDE	R	23.2	21.6	22.4	28.0	26.0	27.0	30.6	28.8	29.7	33.2	31.5	32.4	0.2	250
mg/L	T													mg/L	mg/L
COLOUR TCU	R													0.5	5
	T													TCU	TCU
CONDUCTIVITY	R	800	650	725	712	674	693	719	718	718.5	758	698	728	0.01	
umho/cm	T													UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

M'OS

TABLE 4.0 PLANT K-18 WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		19_83			1984			19_85			19_86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE	R														
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R	.07	.07	.07	.09	.07	.08	.08	.07	.08	.07	.05	.06	0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	367.0	278.7	322.9	369.9	356.6	362.8	396.0	380.7	388.4	402.0	342.0	372	0.5	
mg/L	T													mg/L	
MAGNESIUM	R							31.00	30.00	30.5	31.70	30.60	31.2	0.05	
mg/L	T													mg/L	c
NITRATE	R							.85	.80	.83	.75	.65	.70	0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R													0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R							.10<	.10<	.10<	<.20<	<.10<		0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	7.90	7.46	7.68	7.44	7.29	7.31	7.40	7.36	7.38	8.10	7.94	8.02		
	T														
PHOSPHORUS FILTERED REACTIVE	R													0.01	
mg/L	T													mg/L	

TABLE 4.0

PLANT K-18

WPOS
WATER QUALITY - 4-YEAR SUMMARY (   )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R							.020<	.010<		<.020<	<.010<		0.01	
mg/L	T													mg/L	
SODIUM	R	9.5	7.0	8.3	11.4	8.5	10.0	11.6	10.4	11.0	12.4	11.6	12.0	0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R													0.01	1
FTU	T													FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

WPOS

TABLE 4.0 PLANT K-18 WATER QUALITY - 4-YEAR SUMMARY ( )

METALS (Cont'd)			1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM	mg/L	R													0.001	0.05
		T													mg/L	mg/L
COBALT	mg/L	R													0.001	
		T													mg/L	
COPPER	mg/L	R													0.001	1
		T													mg/L	mg/L
CYANIDE	mg/L	R													0.001	0.2
		T													mg/L	mg/L
IRON	mg/L	R													0.002	0.3
		T	1.09	.01<	0.55	.02<	.01<		.01<	<.005<		<.005<	.036		mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE	mg/L	R							.051	.022	.037	.049	.045	.049	0.001	0.05
		T													mg/L	mg/L
MOLYBDENUM	mg/L	R													0.001	
		T													mg/L	
MERCURY	ug/L	R													0.01	1
		T													ug/L	ug/L
NICKEL	mg/L	R													0.002	
		T													mg/L	

NOTE: Data source is the Region of Waterloo water quality records
Sample frequency twice annually

TABLE 4.0

WPOS

PLANT MANNHEIM PUMP STN. WATER QUALITY - 4-YEAR SUMMARY (   )

GENERAL CHEMISTRY		1983			19 84			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY mg/L	R	256.6	249.4	253	257.6	256.4	257	254.0	247.0	250.5	258.8	221.2	240	0.2 mg/L	
	T														
AMMONIUM TOTAL mg/L	R							.15 <	<.05<		<.05<	<.05<		0.05 mg/L	
	T														
CALCIUM mg/L	R							92.0	89.0	90.5	91.2	71.1	81.2	0.1 mg/L	
	T														
CHLORIDE mg/L	R	21.2	14.0	17.6	17.0	14.6	15.8	19.0	17.0	18.0	18.7	17.8	18.3	0.2 mg/L	250 mg/L
	T														
COLOUR TCU	R													0.5 TCU	5 TCU
	T														
CONDUCTIVITY umho/cm	R	635	628	631.5	626	598	612	633	609	621	627	572	595	0.01 UMHO/CM	
	T														
FIELD CHLORINE (COMBINED) mg/L	R													0.1 mg/L	
	T														
FIELD CHLORINE (FREE) mg/L	R													0.1 mg/L	
	T														
FIELD CHLORINE (TOTAL) mg/L	R													0.1 mg/L	
	T														
FIELD PH	R													0.2	
	T														

TABLE 4.0

WPOS

PLANT MANNHEIM PUMP STN. WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE	R														
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R	.08	.08	.08	.11	.08	.10	.09	.08	.09	.08	.06	.07	0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	337.7	332.3	335.0	327.2	317.2	322.2	335.0	329.3	332.2	331.0	277.0	304	0.5	
mg/L	T													mg/L	
MAGNESIUM	R							26.00	25.50	25.8	25.10	24.20	24.7	0.05	
mg/L	T													mg/L	c
NITRATE	R							3.80	3.40	3.60	3.60	3.15	3.38	0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R													0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R							.10<	.10<		<.10<	.20<		0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	7.93	7.60	7.77	7.59	7.54	7.57	7.64	7.62	7.63	8.17	8.12	8.15		
	T														
PHOSPHORUS FILTERED REACTIVE	R													0.01	
mg/L	T													mg/L	

WPOS

TABLE 4.0 PLANT MANNHEIM PUMP STN. WATER QUALITY - 4-YEAR SUMMARY (   )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R							.020<	.010<		<.020<	<.010<		0.01	
mg/L	T													mg/L	
SODIUM	R	8.0	7.5	7.8	8.6	6.5	7.6	8.0	7.9	8.0	9.4	8.3	8.9	0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R													0.01	1
FTU	T													FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 4.0

WPOS

PLANT MANNHEIM PUMP STN. WATER QUALITY – 4-YEAR SUMMARY ( )

METALS (Cont'd)			1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM		R													0.001	0.05
	mg/L	T													mg/L	mg/L
COBALT		R													0.001	
	mg/L	T													mg/L	
COPPER		R													0.001	1
	mg/L	T													mg/L	mg/L
CYANIDE		R													0.001	0.2
	mg/L	T													mg/L	mg/L
IRON		R	.02	.01<	.02	.02<	.01<	.02<	.03<	<.005<	.02<	.025	.006	.016	0.002	0.3
	mg/L	T													mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE		R							.012<	.006	.009	.009	.004	.0065	0.001	0.05
	mg/L	T													mg/L	mg/L
MOLYBDENUM		R													0.001	
	mg/L	T													mg/L	
MERCURY		R													0.01	1
	ug/L	T													ug/L	ug/L
NICKEL		R													0.002	
	mg/L	T													mg/L	

NOTE: Data source is the Region of Waterloo water quality records
Sample frequency twice annually

TABLE 4.0

WPOS

PLANT K-80 WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY	R				201.0	189.2	195.1	223.8	209.6	216.7	230.1	222.9	226.5	0.2	
mg/L	T													mg/L	
AMMONIUM TOTAL	R							.05<	<.05<	.05<	<.05<	<.05<	.05<	0.05	
mg/L	T													mg/L	
CALCIUM	R							73.0	70.0	71.5	76.1	71.2	73.7	0.1	
mg/L	T													mg/L	
CHLORIDE	R				34.0	29.2	31.6	30.0	28.0	29.0	34.10	20.40	27.3	0.2	250
mg/L	T													mg/L	mg/L
COLOUR TCU	R													0.5	5
	T													TCU	TCU
CONDUCTIVITY	R				528	512	520	590	574	582	615	527	571	0.01	
umho/cm	T													UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

TABLE 4.0 PLANT K-80

WPOS
WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		19 83			19 84			19 85			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE °C	R T														
FIELD TURBIDITY FTU	R T														1 FTU
FLUORIDE mg/L	R T				.13	.12	.13	.14	.09	.12	.12	.07	.10	0.01 mg/L	2.4 mg/L
HARDNESS mg/L	R T				250.9	247.6	249.3	273.0	226.3	249.7	277.0	256.5	266.8	0.5 mg/L	
MAGNESIUM mg/L	R T							22.00	20.00	21.00	21.10	19.10	20.1	0.05 mg/L	c
NITRATE mg/L	R T							4.50	.45	2.48	3.65	1.35	2.5	0.05 mg/L	10 mg/L as N
NITRITE mg/L	R T													0.005 mg/L	1 mg/L as N
NITROGEN TOTAL KJELDAHL mg/L	R T							.40<	.30<	.35<	.20<	<.10<	.15<	0.1 mg/L	0.15 mg/L *
PH	R T				7.58	7.47	7.53	7.77	7.52	7.65	8.45	7.96	8.21		
PHOSPHORUS FILTERED REACTIVE mg/L	R T													0.01 mg/L	

TABLE 4.0

PLANT K-80

WPOS
WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R							.020<	<.010<	.015<	<.020<	<.010	.015<	0.01	
mg/L	T													mg/L	
SODIUM	R				22.0	20.6	21.3	19.8	14.0	16.9	21.7	14.2	18.0	0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R													0.01	1
FTU	T													FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 4.0

PLANT K-80

WPOS
WATER QUALITY - 4-YEAR SUMMARY (   )

METALS (Cont'd)			1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM	mg/L	R													0.001 mg/L	0.05 mg/L
		T														
COBALT	mg/L	R													0.001 mg/L	
		T														
COPPER	mg/L	R													0.001 mg/L	1 mg/L
		T														
CYANIDE	mg/L	R													0.001 mg/L	0.2 mg/L
		T														
IRON	mg/L	R				.03<	.01<	.02<	.05<	.011	.031	.018	.012	.015	0.002 mg/L	0.3 mg/L c
		T														
LEAD	mg/L	R													0.003 mg/L	0.05 mg/L
		T														
MANGANESE	mg/L	R							.055	.005<	.03	.130	.008	.069	0.001 mg/L	0.05 mg/L
		T														
MOLYBDENUM	mg/L	R													0.001 mg/L	
		T														
MERCURY	ug/L	R													0.01 ug/L	1 ug/L
		T														
NICKEL	mg/L	R													0.002 mg/L	
		T														

NOTE: Data source is the Region of Waterloo water quality records
Sample frequency twice annually

TABLE 4.0 PLANT K-81 WPOS WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY mg/L	R	228.2	196.8	212.5	204.6	198.2	201.4	206.6	201.8	204.2	243.6	228.4	236	0.2 mg/L	
	T														
AMMONIUM TOTAL mg/L	R							.05<	<.05<	.05<	.05<	<.05<	.05<	0.05 mg/L	
	T														
CALCIUM mg/L	R							70.0	69.9	70.0	79.4	79.0	79.2	0.1 mg/L	
	T														
CHLORIDE mg/L	R	28.2	26.2	27.2	36.2	26.2	31.2	28.8	28.6	28.7	38.75	21.20	29.98	0.2 mg/L	250 mg/L
	T														
COLOUR TCU	R													0.5 TCU	5 TCU
	T														
CONDUCTIVITY umho/cm	R	602	568	585	573	516	544.5	568	541	554.5	640	557	598.5	0.01 UMHO/CM	
	T														
FIELD CHLORINE (COMBINED) mg/L	R													0.1 mg/L	
	T														
FIELD CHLORINE (FREE) mg/L	R													0.1 mg/L	
	T														
FIELD CHLORINE (TOTAL) mg/L	R													0.1 mg/L	
	T														
FIELD PH	R													0.2	
	T														

TABLE 4.0 PLANT K-81

WPOS
WATER QUALITY - 4-YEAR SUMMARY (   )

GENERAL CHEMISTRY (Cont'd)		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE °C	R T														
FIELD TURBIDITY FTU	R T														1 FTU
FLUORIDE mg/L	R T	.12	.10	.11	.16	.09	.13	.12	.11	.12	.11	.09	.10	0.01 mg/L	2.4 mg/L
HARDNESS mg/L	R T	299.6	282.5	291.1	283.3	250.8	267.1	259.2	255.0	257.1	287.5	282.0	284.75	0.5 mg/L	
MAGNESIUM mg/L	R T							20.5	20.0	20.3	21.7	20.60	21.2	0.05 mg/L	c
NITRATE mg/L	R T							4.45	1.80	3.13	3.80	1.55	2.68	0.05 mg/L	10 mg/L as N
NITRITE mg/L	R T													0.005 mg/L	1 mg/L as N
NITROGEN TOTAL KJELDAHL mg/L	R T							.30<	.20<	.25<	.40<	<.10	.25<	0.1 mg/L	0.15 mg/L *
PH	R T	7.78	7.60	7.69	7.70	7.45	7.68	7.50	7.50	7.50	8.39	8.12	8.26		
PHOSPHORUS FILTERED REACTIVE mg/L	R T													0.01 mg/L	

TABLE 4.0

WPOS

PLANT K-81 WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		19 83			19 84			1985			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R							.020<	.020<	.020<	<.020<	<.010<	.015<	0.01	
mg/L	T													mg/L	
SODIUM	R													0.1	
mg/L	T	16.5	10.0	13.3	21.3	14.0	17.7	17.3	13.8	15.6	23.0	12.6	17.8	mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R													0.01	1
FTU	T													FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 4.0

WPOS

PLANT K-81 WATER QUALITY – 4-YEAR SUMMARY ( )

METALS (Cont'd)			1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM		R													0.001	0.05
	mg/L	T													mg/L	mg/L
COBALT		R													0.001	
	mg/L	T													mg/L	
COPPER		R													0.001	1
	mg/L	T													mg/L	mg/L
CYANIDE		R													0.001	0.2
	mg/L	T													mg/L	mg/L
IRON		R	.03	.01<	.02	.03<	.01<	.02<	.06<	.017<	.04<	.060	.018	.039	0.002	0.3
	mg/L	T													mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE		R							.066	.008	.037	.094	.019	.057	0.001	0.05
	mg/L	T													mg/L	mg/L
MOLYBDENUM		R													0.001	
	mg/L	T													mg/L	
MERCURY		R													0.01	1
	ug/L	T													ug/L	ug/L
NICKEL		R													0.002	
	mg/L	T													mg/L	

NOTE: Data source is the Region of Waterloo water quality records
Sample frequency twice annually

TABLE 4.0 PLANT K-82 WPOS WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY		1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY	R	207.6	163.6	185.6	225.8	210.4	218.1	220.0	214.2	217.1	247.5	232.7	240.1	0.2	
mg/L	T													mg/L	
AMMONIUM TOTAL	R							.05<	<.05<	.05<	<.05<	<.05<	.05<	0.05	
mg/L	T													mg/L	
CALCIUM	R							79.0	79.0	79.0	89.1	79.0	84.1	0.1	
mg/L	T													mg/L	
CHLORIDE	R	35.6	26.0	30.8	30.8	27.4	29.1	27.4	24.8	26.1	37.05	25.30	31.18	0.2	250
mg/L	T													mg/L	mg/L
COLOUR TCU	R													0.5	5
	T													TCU	TCU
CONDUCTIVITY	R	647	615	631	650	575	613	644	581	613	700	591	646	0.01	
umho/cm	T													UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

TABLE 4.0

PLANT K-82 WPOS WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		19 83			19 84			19 85			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE °C	R T														
FIELD TURBIDITY FTU	R T														1 FTU
FLUORIDE mg/L	R T	.21	.19	.20	.20	.15	.18	.16	.15	.16	.17	.12	.15	0.01 mg/L	2.4 mg/L
HARDNESS mg/L	R T	317.8	309.0	313.4	337.5	296.5	317	304.3	292.0	298.2	334.5	289.0	311.8	0.5 mg/L	
MAGNESIUM mg/L	R T							26.00	23.00	24.5	27.20	22.30	24.75	0.05 mg/L	c
NITRATE mg/L	R T							5.30	4.00	4.65	5.05	3.10	4.08	0.05 mg/L	10 mg/L as N
NITRITE mg/L	R T													0.005 mg/L	1 mg/L as N
NITROGEN TOTAL KJELDAHL mg/L	R T													0.1 mg/L	0.15 mg/L *
PH	R T	8.10	7.55	7.83	7.72	7.45	7.59	7.54	7.50	7.52	8.47	8.14	8.31		
PHOSPHORUS FILTERED REACTIVE mg/L	R T													0.01 mg/L	

WPOS

TABLE 4.0 PLANT K-82 WATER QUALITY - 4-YEAR SUMMARY ( )

GENERAL CHEMISTRY (Cont'd)		19 83			19 84			19 85			19 86			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R							.020<	.020<	.020<	<.020<	<.010<	<.015<	0.01	
mg/L	T													mg/L	
SODIUM	R	14.5	14.2	14.35	16.0	13.6	14.8	14.5	13.8	14.2	18.9	14.8	16.9	0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R													0.01	1
FTU	T													FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 4.0

WPOS

PLANT K-82 WATER QUALITY - 4-YEAR SUMMARY ( )

METALS (Cont'd)			1983			1984			1985			1986			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM	mg/L	R													0.001 mg/L	0.05 mg/L
		T														
COBALT	mg/L	R													0.001 mg/L	
		T														
COPPER	mg/L	R													0.001 mg/L	1 mg/L
		T														
CYANIDE	mg/L	R													0.001 mg/L	0.2 mg/L
		T														
IRON	mg/L	R	.02	.02<	.02	.27	.05	.16	.03<	.021	.026	.036	.020	.028	0.002 mg/L	0.3 mg/L c
		T														
LEAD	mg/L	R													0.003 mg/L	0.05 mg/L
		T														
MANGANESE	mg/L	R							.039	.016<	.028	.054	.024	.039	0.001 mg/L	0.05 mg/L
		T														
MOLYBDENUM	mg/L	R													0.001 mg/L	
		T														
MERCURY	ug/L	R													0.01 ug/L	1 ug/L
		T														
NICKEL	mg/L	R													0.002 mg/L	
		T														

NOTE: Data source is the Region of Waterloo water quality records
Sample frequency twice annually

Table A - Footnotes

1 = see individual footnotes for Agency of guideline origin
c = California State Department of Health Action Level
d = OWDD for DDT (contains other isomers such as OPDDT and PPDDT)
e = USEPA ambient guideline
ea = United States Environmental Protection Agency (USEPA) ambient level for endosulfan (contains other isomers)
ep = USEPA proposod maximum contaminant level for drinking water
g = suggested Health and Welfare Canada/Ontario Ministry of the Environment guideline value
h = World Health Organization (WHO) guideline
h* = World Health Organization (WHO) Odour Threshold
mg/L = milligrams per litre, parts per million, (ppm)
ng/L = nanograms per litre, parts per trillion, (ppt)
Presence/Absence = microbiological test to indicate presence or absence of coliform bacteria
R = raw water
T = Treated Drinking Water
t = ODWO Interim maximum acceptable concentration, (IMAC)
ug/L = micrograms per litre, parts per billion, (ppb)
y = New York State (Taste and Odour) proposed drinking water guideline
++ = total Trihalomethanes
+++ = combined total: Heptachlor and Heptachlor Epoxide
* = if other than DWSP Detection Limit
** = total of Aldrin and Dieldrin
*** = Chlordane is a mixture of alpha and gamma isomers
! = Ministry of the Environment and Health and Welfare Canada, (IMAC)

TABLE 5.0: ALGAE COUNT

Page 1 of 1

MONTH	COUNT				
JAN	Max. Min. Avg. No. Tests				
FEB	Max. Min. Avg. No. Tests				
MAR	Max. Min. Avg. No. Tests				
APR	Max. Min. Avg. No. Tests				
MAY	Max. Min. Avg. No. Tests				
JUN	Max. Min. Avg. No. Tests				

NOTE: This table was not applicable to the Kitchener WPOS because the water supply source is ground water

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. Pump Stn. **Page 1 of 1**

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R			0/5	2/3	0/5	0/5	0/5	0/5
	T	0/3	0/3						
FEB	R			0/4	0/4	0/4	0/4	0/4	0/4
	T	0/4	0/4						
MAR	R			0/4	1/3	0/4	1/3	0/4	0/4
	T	0/4	0/4						
APR	R			0/5	0/5	0/4	3/1	0/4	0/4
	T	0/5	0/5						
MAY	R			0/3	1/2	0/4	0/4	0/5	0/5
	T	0/4	0/4						
JUN	R			0/4	2/2	0/4	2/2	0/4	0/4
	T	0/5	0/5						
JUL	R			0/5	3/2	0/5	2/3	0/4	0/4
	T	0/4	0/4						
AUG	R					0/4	1/3	0/5	0/5
	T	0/4	0/4	0/4	0/4				
SEP	R					0/4	1/3	0/4	0/4
	T	0/5	0/5	0/5	0/5				
OCT	R					0/5	2/3	0/5	0/5
	T	0/4	0/4	0/4	0/4				
NOV	R					0/4	2/2	0/4	0/4
	T	0/3	0/3	0/4	0/4				
DEC	R					0/3	1/2	0/4	0/4
	T	0/1	0/1	0/5	0/5				

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated.
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. K10

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R			0/2	0/2	0/5	1/4	0/0	0/0
	T	0/1	0/1						
FEB	R			0/2	0/2	0/4	0/4	0/0	0/0
	T	0/2	0/2						
MAR	R			0/2	0/2	0/4	0/4	0/3	2/1
	T	0/1	0/1						
APR	R			0/3	0/3	0/4	0/4	0/4	0/4
	T	0/2	0/2						
MAY	R			0/2	0/2	0/4	0/4	0/4	0/4
	T	0/2	0/2						
JUN	R			0/2	0/2	0/2	0/2	0/4	0/4
	T	0/3	0/3						
JUL	R			1/1	1/1	0/3	0/3	0/4	0/4
	T	0/2	0/2						
AUG	R					0/2	0/2	0/5	0/5
	T	0/2	0/2	0/2	0/2				
SEP	R					0/2	0/2	0/4	0/4
	T	0/2	0/2	0/2	0/2				
OCT	R					0/2	0/2	0/5	1/4
	T	0/2	0/2	0/2	0/2				
NOV	R					0/2	0/2	1/3	0/4
	T	0/1	0/1	0/2	0/2				
DEC	R					0/2	0/2	0/3	0/3
	T	0/1	0/1	0/3	0/3				

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination is provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. K11

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R			0/3	0/3	0/5	0/5	0/5	0/5
	T	0/2	0/2						
FEB	R			0/2	0/2	0/4	0/4	0/4	0/4
	T	0/2	0/2						
MAR	R			0/2	0/2	0/4	0/4	0/4	0/4
	T	0/2	0/2						
APR	R			0/2	0/2	0/4	0/4	0/4	0/4
	T	0/3	0/3						
MAY	R			0/2	0/2	0/4	0/4	0/5	0/5
	T	0/2	0/2						
JUN	R			0/2	0/2	0/2	0/2	0/4	0/4
	T	0/2	0/2	0/2					
JUL	R			0/3	0/3	0/3	0/3	0/4	0/4
	T	0/2	0/2						
AUG	R					0/2	0/2	0/5	0/5
	T	0/2	0/2	0/2	0/2				
SEP	R					0/2	0/2	0/4	0/4
	T	0/3	0/3	0/3	0/3				
OCT	R					0/2	0/2	0/5	0/5
	T	0/2	0/2	0/0	0/0				
NOV	R					0/2	0/2	0/4	0/4
	T	0/2	0/2	0/2	0/2				
DEC	R					0/2	0/2	0/3	0/3
	T	0/0	0/0	0/2	0/2				

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.

2. R= Raw; T=Treated

3. Data source is Region of Waterloo bacteriological testing records

4. Chlorination is provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. K12

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R								
	T	0/1	0/1	0/2	0/2	0/0	0/0	0/5	0/5
FEB	R								
	T	0/2	0/2	0/2	0/2	0/0	0/0	0/4	0/4
MAR	R								
	T	0/2	0/2	0/2	0/2	0/0	0/0	0/3	0/3
APR	R								
	T	0/2	0/2	0/3	0/3	0/0	0/0	0/4	0/4
MAY	R								
	T	0/2	0/2	0/2	0/2	0/0	0/0	0/5	0/5
JUN	R								
	T	0/3	0/3	0/2	0/2	0/0	0/0	0/3	0/3
JUL	R								
	T	0/2	0/2	0/2	0/2	0/1	0/1	0/0	0/0
AUG	R								
	T	0/1	0/1	0/2	0/2	0/1	0/1	0/1	0/1
SEP	R								
	T	0/0	0/0	0/2	0/2	0/2	0/2	0/2	0/2
OCT	R								
	T	0/0	0/0	0/2	0/2	0/3	0/3	0/1	0/1
NOV	R								
	T	0/0	0/0	0/2	0/2	0/2	0/2	0/0	0/0
DEC	R								
	T	0/0	0/0	0/3	0/3	0/1	0/1	0/0	0/0

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. K13

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R			0/3	0/3	0/4	0/4	0/5	0/5
	T	0/1	0/1						
FEB	R			0/2	0/2	0/4	0/4	0/4	0/4
	T	0/2	0/2						
MAR	R			0/2	0/2	0/4	0/4	0/4	0/4
	T	0/2	0/2						
APR	R			0/2	0/2	0/3	0/3	0/3	0/3
	T	0/4	0/4						
MAY	R			0/2	0/2	0/4	0/4	0/3	0/3
	T	0/2	0/2						
JUN	R			0/2	0/2	0/2	0/2	0/3	0/3
	T	0/2	0/2						
JUL	R			0/3	0/3	0/2	0/2	0/4	0/4
	T	0/2	0/2						
AUG	R			0/2	0/2	0/2	0/2	0/4	0/4
	T	0/2	0/2						
SEP	R			0/3	0/3	0/2	0/2	0/2	0/2
	T	0/3	0/3						
OCT	R			0/2	0/2	0/2	0/2	0/5	0/5
	T	0/2	0/2						
NOV	R			0/2	0/2	0/2	0/2	0/4	0/4
	T	0/2	0/2						
DEC	R			0/2	0/2	0/1	0/1	0/3	0/3
	T	0/0	0/0						

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination is provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. K14

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/0	0/0	0/5	0/5	0/5	0/5	0/5	0/5
	T								
FEB	R	0/0	0/0	0/4	0/4	0/4	0/4	0/4	0/4
	T								
MAR	R	0/0	0/0	0/4	0/4	0/4	0/4	0/2	0/2
	T								
APR	R	0/0	0/0	0/5	0/5	0/0	0/0	0/3	0/3
	T								
MAY	R	0/0	0/0	0/4	0/4	0/3	0/3	0/5	0/5
	T								
JUN	R	0/5	1/4	0/4	0/4	0/4	0/4	0/4	0/4
	T								
JUL	R	0/4	0/4	0/5	0/5	0/5	0/5	0/4	0/4
	T								
AUG	R	0/4	0/4	0/4	0/4	0/4	0/4	0/5	0/5
	T								
SEP	R	0/5	0/5	0/5	0/5	0/4	0/4	0/4	0/4
	T								
OCT	R	0/4	0/4	0/4	0/4	0/5	0/5	0/5	0/5
	T								
NOV	R	0/3	0/3	0/0	0/0	0/4	1/3	0/4	0/4
	T								
DEC	R	0/1	0/1	0/0	0/0	0/3	0/3	0/4	0/4
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. K17

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/1	1/0	0/2	0/2	0/5	0/5	0/5	0/5
	T								
FEB	R	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
	T								
MAR	R	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
	T								
APR	R	0/2	0/2	0/3	0/3	0/4	0/4	0/4	0/4
	T								
MAY	R	0/2	0/2	0/2	0/2	0/1	0/1	0/5	0/5
	T								
JUN	R	0/3	0/3	0/2	0/2	0/2	0/2	0/4	0/4
	T								
JUL	R	0/2	0/2	0/2	2/0	0/2	0/2	0/4	0/4
	T								
AUG	R	0/2	0/2	0/2	2/0	0/2	0/2	0/4	0/4
	T								
SEP	R	0/2	0/2	0/2	1/1	0/2	0/2	0/4	0/4
	T								
OCT	R	0/2	0/2	0/2	0/2	0/3	0/3	0/5	0/5
	T								
NOV	R	0/1	0/1	0/2	0/2	0/2	0/2	0/4	0/4
	T								
DEC	R	0/1	0/1	0/4	0/4	0/1	0/1	0/3	0/3
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Strange St. K18 Page 1 of 1

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R T	0/3	0/3	0/5	0/5	0/5	0/5	0/4	0/4
FEB	R T	0/4	0/4	0/4	0/4	0/3	0/3	0/4	0/4
MAR	R T	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
APR	R T	0/5	0/5	0/5	0/5	0/5	0/5	0/2	0/2
MAY	R T	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
JUN	R T	0/5	0/5	0/4	0/4	0/4	0/4	0/4	1/3
JUL	R T	0/4	0/4	0/5	0/5	0/5	0/5	0/4	0/4
AUG	R T	0/4	0/4	0/3	0/3	0/4	0/4	0/5	0/5
SEP	R T	0/5	0/5	0/5	0/5	0/4	0/4	0/4	0/4
OCT	R T	0/4	0/4	0/3	0/3	0/5	0/5	0/5	0/5
NOV	R T	0/3	0/3	0/4	0/4	0/4	0/4	0/3	0/3
DEC	R T	0/1	0/1	0/5	0/5	0/3	0/3	0/4	0/4

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.

2. R= Raw; T=Treated

3. Data source is Region of Waterloo bacteriological testing records

4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Kitchener Distribution System - PUC - Alice Ave.

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/4	0/4	0/5	0/5				
	T								
FEB	R	0/4	0/4	0/4	0/4				
	T								
MAR	R	0/4	0/4	0/4	0/4				
	T								
APR	R	0/5	0/5	0/5	0/5				
	T								
MAY	R	0/4	2/2	0/4	0/4				
	T								
JUN	R	0/5	1/4	0/4	0/4				
	T								
JUL	R	0/4	0/4	0/5	0/5				
	T								
AUG	R	0/4	0/4	0/4	0/4				
	T								
SEP	R	0/5	0/5	0/4	0/4				
	T								
OCT	R	0/4	0/4	0/4	0/4				
	T								
NOV	R	0/4	0/4	0/4	0/4				
	T								
DEC	R	0/5	1/4	0/5	0/5				
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.

2. R= Raw; T=Treated

3. Data source is Region of Waterloo bacteriological testing records

4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Kitchener Distribution System - PUC - Joseph St. **Page 1 of 1**

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/4	0/4	0/5	0/5				
	T								
FEB	R	0/4	0/4	0/4	0/4				
	T								
MAR	R	0/4	0/4	0/4	0/4				
	T								
APR	R	0/5	1/4	0/5	0/5				
	T								
MAY	R	0/4	0/4	0/4	0/4				
	T								
JUN	R	0/5	0/5	0/4	0/4				
	T								
JUL	R	0/4	2/2	0/5	0/5				
	T								
AUG	R	0/4	1/3	0/4	0/4				
	T								
SEP	R	0/5	1/4	0/4	1/3				
	T								
OCT	R	0/4	0/4	0/4	0/4				
	T								
NOV	R	0/4	0/4	0/4	0/4				
	T								
DEC	R	0/5	0/5	0/5	1/4				
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records.
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Mannheim Pump Stn.

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/4	0/4	0/5	2/3	0/5	0/5	0/5	0/5
	T								
FEB	R	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
	T								
MAR	R	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
	T								
APR	R	0/5	0/5	0/5	0/5	0/5	0/5	0/4	0/4
	T								
MAY	R	0/4	1/3	0/4	1/3	0/4	0/4	0/5	0/5
	T								
JUN	R	0/5	1/4	0/4	0/4	0/4	3/1	0/4	1/3
	T								
JUL	R	0/4	4/0	0/5	2/3	0/5	0/5	0/4	1/3
	T								
AUG	R	0/4	3/1	1/3	1/3	0/4	0/4	0/5	1/4
	T								
SEP	R			0/5	2/3	0/4	1/3	0/4	0/4
	T	0/5	0/5						
OCT	R			0/4	1/3	0/5	2/3	0/5	0/5
	T	0/4	0/4						
NOV	R			0/4	3/1	0/4	0/4	0/3	1/2
	T	0/3	1/2						
DEC	R			0/5	2/3	0/3	0/3	0/3	0/3
	T	0/0	0/0						

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Mannheim K21

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/2	0/2	0/3	0/3	0/5	0/5	0/5	0/5
	T								
FEB	R	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
	T								
MAR	R	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
	T								
APR	R	0/3	0/3	0/2	0/2	0/5	0/5	0/4	0/4
	T								
MAY	R	0/2	0/2	0/2	0/2	0/4	0/4	0/5	0/5
	T								
JUN	R	0/1	0/1	0/2	0/2	0/2	0/2	0/4	0/4
	T								
JUL	R	0/2	0/2	0/3	0/3	0/3	0/3	0/4	0/4
	T								
AUG	R	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
	T								
SEP	R			0/3	0/3	0/2	0/2	0/4	0/4
	T	0/2	0/2						
OCT	R			0/2	0/2	0/2	0/2	0/5	0/5
	T	0/2	0/2						
NOV	R			0/2	0/2	0/2	0/2	0/3	0/3
	T	0/1	0/1						
DEC	R			0/2	0/2	0/2	0/2	0/4	0/4
	T	0/0	0/0						

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data siyrce us Region of Waterloo bacteriological testing records
4. Chlorination is provided

TABLE 6.0; BACTERIOLOGICAL TESTING - Mannheim K22

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/2	0/2	0/2	0/2	0/5	0/5	0/5	0/5
	T								
FEB	R	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
	T								
MAR	R	0/2	0/2	0/2	1/1	0/0	0/0	0/4	0/4
	T								
APR	R	0/2	0/2	0/3	0/3	0/4	0/4	0/4	0/4
	T								
MAY	R	0/2	0/2	0/2	0/2	0/4	0/4	0/5	0/5
	T								
JUN	R	0/4	0/4	0/2	0/2	0/2	0/2	0/4	0/4
	T								
JUL	R	0/2	0/2	0/2	0/2	0/2	0/2	0/4	0/4
	T								
AUG	R	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
	T								
SEP	R	0/2	0/2	0/2	0/2	0/2	0/2	0/4	0/4
	T								
OCT	R	0/2	0/2	0/2	0/2	0/3	0/3	0/5	0/5
	T								
NOV	R	0/1	0/1	0/2	0/2	0/2	0/2	0/3	0/3
	T								
DEC	R	0/1	0/1	0/3	0/3	0/1	0/1	0/3	0/3
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Mannheim K23

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R T	0/2	0/2	0/3	0/3	0/5	0/5	0/5	0/5
FEB	R T	0/2	0/2	0/2	1/1	0/4	0/4	0/4	0/4
MAR	R T	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
APR	R T	0/2	0/2	0/2	0/2	0/5	0/5	0/4	0/4
MAY	R T	0/2	1/1	0/2	1/1	0/4	0/4	0/5	0/5
JUN	R T	0/2	0/2	0/2	0/2	0/2	0/2	0/4	0/4
JUL	R T	0/2	0/2	0/3	0/3	0/3	0/3	0/4	0/4
AUG	R T	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
SEP	R T	0/2	0/2	0/3	0/3	0/2	0/2	0/4	0/4
OCT	R T	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
NOV	R T	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2
DEC	R T	0/0	0/0	0/2	0/2	0/2	0/2	0/3	0/3

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Mannheim K24

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R T	0/2	0/2	0/1	0/1	0/5	0/5	0/5	0/5
FEB	R T	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
MAR	R T	0/2	0/2	0/1	0/1	0/4	0/4	0/4	0/4
APR	R T	0/2	0/2	0/3	0/3	0/4	0/4	0/4	0/4
MAY	R T	0/2	0/2	0/2	0/2	0/4	0/4	0/5	0/5
JUN	R T	0/3	0/3	0/2	0/2	0/2	0/2	0/4	0/4
JUL	R T	0/2	0/2	0/1	0/1	0/3	0/3	0/4	0/4
AUG	R T	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
SEP	R T	0/2	0/2	0/2	0/2	0/2	0/2	0/4	0/4
OCT	R T	0/2	0/2	0/2	0/2	0/3	0/3	0/5	0/5
NOV	R T	0/1	0/1	0/2	0/2	0/2	0/2	0/2	0/2
DEC	R T	0/1	0/1	0/3	0/3	0/1	0/1	0/3	0/3

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Mannheim K25

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/1	0/1	0/3	0/3	0/5	0/5	0/5	0/5
	T								
FEB	R	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
	T								
MAR	R	0/2	0/2	0/2	0/2	0/3	0/3	0/4	0/4
	T								
APR	R	0/3	0/3	0/3	0/2	0/2	0/3	0/4	0/4
	T								
MAY	R	0/1	0/1	0/2	0/2	0/4	0/4	0/5	0/5
	T								
JUN	R	0/2	0/2	0/2	0/2	0/2	0/2	0/4	0/4
	T								
JUL	R	0/2	0/2	0/3	0/3	0/2	0/2	0/4	0/4
	T								
AUG	R	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
	T								
SEP	R	0/2	0/2	0/3	0/3	0/3	0/3	0/4	0/4
	T								
OCT	R	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
	T								
NOV	R	0/2	0/2	0/2	0/2	0/1	0/1	0/3	0/3
	T								
DEC	R	0/0	0/0	0/2	0/2	0/1	0/1	0/3	0/3
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Mannheim K26

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/2	0/2	0/2	0/2	0/5	0/5	0/5	0/5
	T								
FEB	R	0/2	0/2	0/2	0/2	0/4	0/4	0/3	0/3
	T								
MAR	R	0/2	0/2	0/1	0/1	0/4	0/4	0/4	0/4
	T								
APR	R	0/2	0/2	0/3	0/3	0/5	0/5	0/4	0/4
	T								
MAY	R	0/2	0/2	0/1	0/1	0/4	0/4	0/5	0/5
	T								
JUN	R	0/3	0/3	0/2	0/2	0/2	0/2	0/4	0/4
	T								
JUL	R	0/2	0/2	0/2	0/2	0/4	0/4	0/4	0/4
	T								
AUG	R	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
	T								
SEP	R	0/2	0/2	0/2	0/2	0/0	0/0	0/4	0/4
	T								
OCT	R	0/2	0/2	0/2	0/2	0/2	0/2	0/5	0/5
	T								
NOV	R	0/1	0/1	0/2	0/2	0/2	0/2	0/2	0/2
	T								
DEC	R	0/1	0/1	0/3	0/3	0/2	0/2	0/3	0/3
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Kitchener Distribution System - PUC - Elmsdale Dr.

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/4	0/4	0/5	0/5				
	T								
FEB	R	0/4	0/4	0/4	0/4				
	T								
MAR	R	0/4	0/4	0/4	0/4				
	T								
APR	R	0/5	0/5	0/5	0/5				
	T								
MAY	R	0/4	1/3	0/4	0/4				
	T								
JUN	R	0/5	0/5	0/4	0/4				
	T								
JUL	R	0/4	0/4	0/4	1/3				
	T								
AUG	R	0/4	0/4	0/3	1/2				
	T								
SEP	R	0/5	0/5	0/4	3/1				
	T								
OCT	R	0/4	0/4	0/3	0/3				
	T								
NOV	R	0/4	0/4	0/3	0/3				
	T								
DEC	R	0/5	0/5	0/5	0/5				
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.

2. R= Raw; T=Treated

3. Data source is Region of Waterloo bacteriological testing records

4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Kitchener Distribution System - PUC - McGarry & Fisher

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MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/4	0/4	0/5	0/5				
	T								
FEB	R	0/4	0/4	0/4	0/4				
	T								
MAR	R	0/4	1/3	0/4	0/4				
	T								
APR	R	0/5	0/5	0/5	0/5				
	T								
MAY	R	0/4	0/4	0/4	0/4				
	T								
JUN	R	0/5	0/5	0/4	0/4				
	T								
JUL	R	0/4	2/2	0/4	0/4				
	T								
AUG	R	0/4	1/3	0/3	0/3				
	T								
SEP	R	0/5	0/5	0/4	0/4				
	T								
OCT	R	0/4	0/4	0/3	1/2				
	T								
NOV	R	0/4	0/4	0/3	1/2				
	T								
DEC	R	0/5	0/5	0/5	0/5				
	T								

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.

2. R= Raw; T=Treated

3. Data source is Region of Waterloo bacteriological testing records

4. Chlorination not provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Woolner K80

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/3	3/0	2/3	5/0	-	-	-	-
	T	0/3	0/3	0/5	0/5	-	-	-	-
FEB	R	0/4	4/0	1/2	2/1	-	-	-	-
	T	0/4	0/4	0/3	0/3	-	-	-	-
MAR	R	0/3	3/0	0/4	4/0	-	-	-	-
	T	0/3	0/3	0/4	1/3	-	-	-	-
APR	R	0/5	5/0	0/2	2/0	-	-	-	-
	T	0/5	1/4	0/2	0/2	-	-	-	-
MAY	R	0/4	4/0	0/4	4/0	-	-	-	-
	T	0/4	0/4	0/4	0/4	-	-	-	-
JUN	R	0/3	1/2	0/4	2/2	-	-	-	-
	T	0/3	0/3	0/4	0/4	-	-	-	-
JUL	R	0/1	0/1	0/1	0/1	-	-	-	-
	T	0/1	0/1	0/1	0/1	-	-	-	-
AUG	R	1/3	2/2	0/4	4/0	0/4	2/2	-	-
	T	0/4	0/4	0/3	0/3	0/4	0/4	-	-
SEP	R	0/2	1/1	-	-	1/3	1/3	-	-
	T	0/2	0/2	-	-	0/4	0/4	-	-
OCT	R	2/2	3/1	-	-	0/5	0/5	-	-
	T	0/4	0/4	-	-	0/5	0/5	-	-
NOV	R	0/3	1/2	0/1	1/0	1/3	4/0	-	-
	T	0/3	0/3	0/1	0/1	0/4	1/3	-	-
DEC	R	0/1	1/0	1/4	5/0	0/3	3/0	-	-
	T	0/1	0/1	0/5	1/4	0/3	0/3	-	-

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination is provided

TABLE 6.0 BACTERIOLOGICAL TESTING - Woolner K81

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MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/3	3/0	2/3	5/0	2/3	5/0	-	-
	T	0/3	0/3	0/5	0/5	0/5	0/5	-	-
FEB	R	0/4	4/0	0/3	3/0	2/2	3/1	-	-
	T	0/4	0/4	0/3	0/3	0/4	0/4	-	-
MAR	R	1/2	2/1	0/4	3/1	1/3	4/0	-	-
	T	0/3	0/3	0/4	0/4	0/4	0/4	-	-
APR	R	0/5	5/0	0/2	2/0	0/5	5/0	1/4	4/1
	T	0/5	0/5	0/2	0/2	0/5	0/5	0/4	0/4
MAY	R	0/4	4/0	0/4	1/3	0/4	3/1	0/4	4/0
	T	0/4	0/4	0/4	0/4	0/4	0/4	0/4	0/4
JUN	R	0/4	1/3	0/4	2/2	0/3	3/0	0/4	0/4
	T	0/4	0/4	0/4	0/4	0/3	0/3	0/4	0/4
JUL	R	0/2	2/0	0/4	1/3	0/5	4/1	0/4	2/2
	T	0/2	0/2	0/4	0/4	0/5	0/5	0/4	0/4
AUG	R	1/3	3/1	0/4	4/0	0/4	4/0	0/3	2/1
	T	0/4	1/3	0/4	0/4	0/4	0/4	0/3	0/3
SEP	R	3/1	4/0	0/2	1/1	0/4	4/0	0/4	3/1
	T	2/2	2/2	0/2	0/2	0/4	0/4	0/4	0/4
OCT	R	1/2	2/1	0/4	1/3	0/5	3/2	1/4	3/2
	T	0/1	0/1	0/4	0/4	0/5	0/5	0/5	0/5
NOV	R	0/3	1/2	0/3	3/0	1/3	2/2	0/4	2/2
	T	0/3	0/3	0/3	0/3	0/4	0/4	0/4	0/4
DEC	R	0/1	1/0	2/3	5/0	1/2	1/2	1/3	4/0
	T	0/1	0/1	0/5	0/5	0/3	0/3	0/4	0/4

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination is provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Woolner K82

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	0/3	1/2	0/5	3/2	0/5	3/2	0/5	2/3
	T	0/3	0/3	0/5	0/5	0/5	0/5	0/5	0/5
FEB	R	0/4	1/3	0/3	1/2	0/4	2/2	0/4	1/3
	T	0/4	0/4	0/3	0/3	0/4	0/4	0/4	0/4
MAR	R	0/3	0/3	0/4	3/1	0/4	1/3	0/3	1/2
	T	0/3	0/3	0/4	0/4	0/4	0/4	0/3	0/3
APR	R	0/5	2/3	0/2	0/2	0/5	2/3	0/3	1/2
	T	0/5	0/5	0/2	0/2	0/5	0/5	0/3	0/3
MAY	R	0/4	1/3	0/4	1/3	0/4	2/2	0/3	1/2
	T	0/4	0/4	0/4	0/4	0/4	0/4	0/3	0/3
JUN	R	0/5	0/5	0/4	2/2	0/3	0/3	0/4	0/4
	T	0/5	0/5	0/4	0/4	0/3	0/3	0/4	0/4
JUL	R	0/4	0/4	0/3	1/2	0/5	0/5	0/4	0/4
	T	0/4	0/4	0/3	0/3	0/5	0/5	0/4	0/4
AUG	R	0/4	0/4	0/4	1/3	0/4	0/4	0/5	2/3
	T	0/4	0/4	0/4	0/4	0/4	0/4	0/5	0/5
SEP	R	1/2	3/0	0/2	0/2	0/4	0/4	0/4	1/3
	T	0/3	0/3	0/2	0/2	0/4	0/4	0/4	0/4
OCT	R	2/2	2/2	0/4	0/4	0/5	1/4	0/5	1/4
	T	0/4	0/4	0/4	0/4	0/5	0/5	0/5	0/5
NOV	R	0/3	0/3	0/3	1/2	0/4	3/1	0/4	0/4
	T	0/3	0/3	0/3	0/3	0/4	0/4	0/4	0/4
DEC	R	0/1	0/1	0/5	1/4	0/3	2/1	0/4	1/3
	T	0/1	0/1	0/5	0/5	0/3	0/3	0/4	0/4

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination is provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Kitchener Distribution System - Stanley Park Public School

Page 1 of 1

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R								
	T	0/4	0/4	0/5	0/5				
FEB	R								
	T	0/4	0/4	0/4	0/4				
MAR	R								
	T	0/4	0/4	0/4	0/4				
APR	R								
	T	0/5	0/5	0/5	0/5				
MAY	R								
	T	0/4	0/4	0/4	0/4				
JUN	R								
	T	0/5	0/5	0/4	0/4				
JUL	R								
	T	0/4	0/4	0/4	0/4				
AUG	R								
	T	0/4	1/3	0/3	0/3				
SEP	R								
	T	0/5	1/4	1/4	1/4				
OCT	R								
	T	0/4	0/4	0/3	0/3				
NOV	R								
	T	0/4	0/4	0/3	0/3				
DEC	R								
	T	0/5	0/5	0/4	0/4				

NOTES:

1. This table shows presence-absence test analysis, e.g.., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination is provided

TABLE 6.0: BACTERIOLOGICAL TESTING - Kitchener Distribution System - Grand River Arena **Page 1 of 1**

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R								
	T	0/4	0/4	0/5	0/5				
FEB	R								
	T	0/4	0/4	0/4	0/4				
MAR	R								
	T	0/4	0/4	0/4	0/4				
APR	R								
	T	0/5	0/5	0/5	0/5				
MAY	R								
	T	0/4	0/4	0/4	0/4				
JUN	R								
	T	0/5	0/5	0/4	0/4				
JUL	R								
	T	0/4	0/4	0/4	0/4				
AUG	R								
	T	0/4	0/4	0/3	0/3				
SEP	R								
	T	0/5	0/5	0/4	0/4				
OCT	R								
	T	0/4	0/4	0/3	0/3				
NOV	R								
	T	0/4	0/4	0/3	0/3				
DEC	R								
	T	0/5	0/5	0/5	0/5				

NOTES:

1. This table shows presence-absence test analysis, e.g., 1/3 shows one monthly sample indicates bacteria present and 3 monthly samples indicate bacteria absent.
2. R= Raw; T=Treated
3. Data source is Region of Waterloo bacteriological testing records
4. Chlorination is provided

APPENDIX C
DWSP PARAMETERS

January 12, 1987

DWSP SCANS AND PARAMETERS

SCAN - DWAPA + CNNAUR + HGUT + PHNOL (METALS AND GENERAL CHEMESTRY)

METALS

UUUT	-	Uranium
FEUT	-	Iron
MNUT	-	Manganese
ALUT	-	Aluminum
ASUT	-	Arsenic
BAUT	-	Barium
BBUT	-	Boron
BEUT	-	Beryllium
CCNAUR	-	Cyanide
CDUT	-	Cadmium
COUT	-	Cobalt
CRUT	-	Chromium
CUUT	-	Copper
HGUT	-	Mercury
MOUT	-	Molybdenum
NIUT	-	Nickel
PBUT	-	Lead
SEUT	-	Selenium
SNUT	-	Tin (no units available)
SRUT	-	Strontium
VVUT	-	Vanadium
ZNUT	-	Zinc

GENERAL CHEMISTRY

COND25	-	Conductivity
HARDT	-	Hardness
CAUR	-	Calcium
MGUR	-	Magnesium
NAUR	-	Sodium
ALKT	-	Alkalinity
PH	-	Ph
FFIDUR	-	Fluoride
CLIDUR	-	Chloride
RST	-	Residue total
TURB	-	Turbidity
COLTR	-	Colour
NNOTFR	-	Nitrates total
NNO2FR	-	Nitrite, Frac, React
PHNOL	-	Phenol

SCAN - DWAPD (NUTRIENTS)

PPUT - Phosphorus
PPO4FR - Phosphates
NNTKUR - Nitr'n Total
NNHTFR - Ammonium

SCAN - MBDWMF+FCMF (BACTI) (RAW ONLY)

TCMF - Total Coliform MF
TCMFBK - Total Coliform MF BKGD
FCMF - Fecal Coliform
HB35MF - Standard Plate Count MF

SCAN - MBMFPA (BACTI) (TREATED ONLY)

PABOT - Present/Absent (P/A) Test
TCMFBK - Total Coliform MF BKGD
FCMF - Fecal Coliform
HB35MF - Standard Plate Count MF

FOLLOWING DONE IF PABOT TEST IS POSITIVE

TCFPA - Coliform P/A
FCPA - Fecal Coliform P/A
ECPA - E. Coli P/A
AEPA - Aromonas P/A
STAPA - Staph. Aureus P/A

SCAN - OPOPUP (OTC PURGEABLE ORGANICS)

X1001P - 1,1-Dichloroethylene (1,1-Dichloroethene)
X1002P - Dichloromethane
X1003P - TRS-1,2-Dichloroethylene (TRS-1,2-Dichloroethene)
X1004P - 1,1-Dichloroethane
X1005P - Chloroform
X1006P - 1,1,1-Trichloroethane
X1007P - 1,2-Dichloroethane
X1008P - Carbon Tetrachloride
B2001P - Benzene
X1009P - 1,2-Dichloropropane
X1010P - Trichloroethylene
X1011P - Dichlorobromomethane
B2002P - Toluene
X1012P - 1,1,2-Trichloroethane
X1013P - Chlorodibromomethane
X1014P - Tetrachloroethylene (Tetrachloroethene)

cont'd ...

X2001P - Chlorobenzene
X2013P - Trifluorochlorotoluene
B2003P - Ethylbenzene
X2EDB - Ethylene Dibromide
B2004P - P-Xylene
B2005P - M-Xylene
B2006P - O-Xylene
X2TTHM - Total Trihalomethanes
X1015P - Bromoform
X1016P - 1,1,2,2-Tetrachloroethane
X2002P - 1,4-Dichlorobenzene
X2003P - 1,3-Dichlorobenzene
X2004P - 1,2-Dichlorobenzene

SCAN - OWTRI (TRIAZINE SCAN)

P3DROP - Propazine
P2ATRA - Atrazine
P2SIM - Simazine
P2SENC - Sencor (Metribuzin)
P2BLAD - Bladex (Cyanazine)
P2PROM - Prometone
P2AMET - Ametryne
P2PROY - Prometryne
P2ATRO - Atratone
POLASS - Alachlor
POMET - Metolachlor

cont'd ...

SCAN - OWOC (ORGANIC WATER DWS)

X2HCE - Hexachloroethane
X2135 - 1,3,5-Trichlorobenzene
X2124 - 1,2,4-Trichlorobenzene
X1HCBD - Hexachlorobutadiene
X2123 - 1,2,3-Trichlorobenzene
X2T245 - 2,4,5-Trichlorotoluene
X2T236 - 2,3,6-Trichlorotoluene
X21235 - 1,2,3,5-Tetrachlorobenzene
X21245 - 1,2,4,5-Tetrachlorobenzene
X2T26A - 2,6,A-Trichlorotoluene
X21234 - 1,2,3,4-Tetrachlorobenzene
X2PNCB - Pentachlorobenzene
P1PCBT - Totals PCB's
X2HCB - Hexachlorobenzene
P1HEPT - Heptachlor
P1ALDR - Aldrin
P1PPDE - PP-DDE
P1MIRX - Mirex
P1BHCA - Alpha Hexachlorocyclohexane (BHC)
P1BHCB - Beta Hexachlorocyclohexane (BHC)
P1BHCG - Gamma Hexachlorocyclohexane (BHC) (Lindane)
P1CHLA - Alpha Chlordane
P1CHLG - Gamma Chlordane
P1OCHL - Oxychlordane
P1OPDT - OP-DDT

cont'd ...

P1PPDD - PP-DDD
P1PPDT - PP-DDT
P1DMDT - Methoxychlor
P1HEPE - Heptachlor Epoxide
P1END1 - Endosulfan 1 (Thiodan 1)
P1DIEL - Dieldrin
P1ENDR - Endrin
P1ENDR2 - Endosulfan 2 (Thiodan 2)
P1ENDS - Endosulfan Sulphate (Thiodan Sulphate)
X2OCST - Octachlorostyrene
P1TOXA - Toxaphene (no units available)

SCAN - OWCP (SPECIAL PESTICIDES)

P3DICA - Dicamba
P324D - 24D
P324DB - 24DB
P324DP - 24DP
P3245T - 245T
P3SILU - Silvex (245TP)
P3PICL - Picloram
X3246 - 2,4,6-Trichlorophenol
X3245 - 2,4,5-Trichlorophenol
X3234 - 2,3,4-Trichlorophenol
X32356 - 2,3,5,6-Tetrachlorophenol
X32345 - 2,3,4,5-Tetrachlorophenol
X3PCPH - Pentachlorophenol

SCAN - PEOP (2 TIMES/YEAR) (SPECIAL PESTICIDES)

P4DIAZ - Diazinon
P4DICH - Dichlovorvos
P4DURS - Dursban
P4ETHI - Ethion
P4GUTH - Guthion
P4MALA - Malathion
P4MEVI - Mevinphos
P4MPAR - Methyl Parathion
P4MTRI - Methyl Trithion
P4PARA - Parathion
P4PHOR - Phorate (Thimet)
P4RELD - Reldan
P4RONN - Ronnel

SCAN - PECAR (2 TIMES/YEAR) (SPECIAL PESTICIDES

P6CARB - Carbofuran
P6PROP - Propoxur
P6IPC - IPC
P6AMIN - Aminocarb
P6CIPC - CIPC
P6EPTM - Eptam
P6BENO - Benonyl
P6BUX - Bux
P6DIAL - Diallate
P6SEVN - Sevin
P6SUTN - Sutan

SCAN - OPODMS (MASS SPEC. SCAN)

CL2CL5 - N-CL2methyleneCL5analine
CL4BPH - CL4 Bipenyl
CL4BUT - Tetrachlorobutane
CL5BUE - Pentachlorobutadiene
CL5PRE - Pentachloropropene
CL5PRO - Pentachloropropane
CL6ENE - Hexachloropropene
DIPHET - Diphenyl Ether
DNBPHT - Di-N-Butyl Phthalate
FLUENE - Fluoranthene
MEPHEN - Methyl Phenanthrene
NAPHNE - Naphthalene
PYRENE - Pyrene